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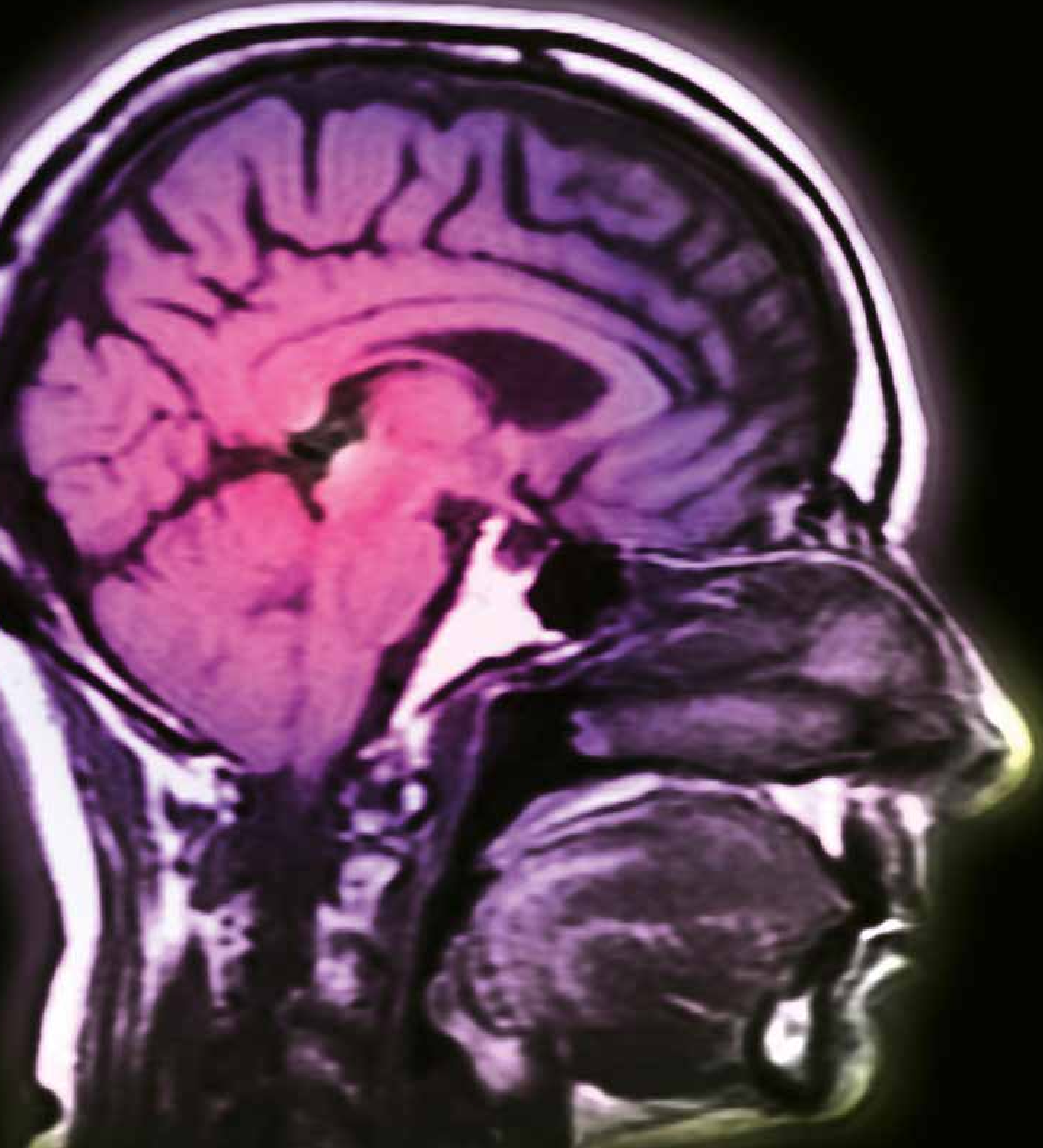
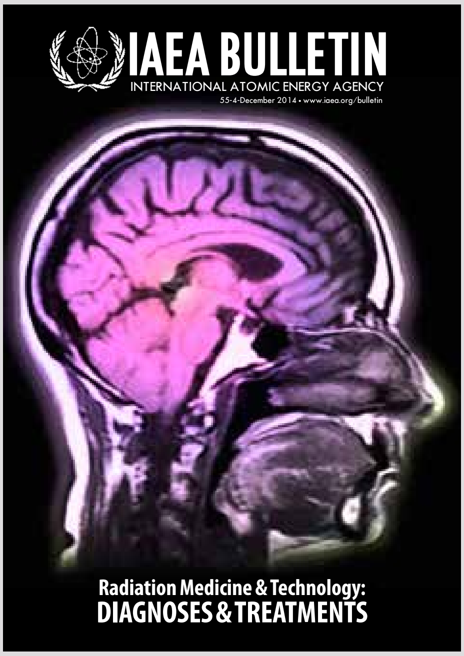


Radiation Medicine & Technology:
DIAGNOSES & TREATMENTS



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Cover:
Radiation medicine and technology contribute to the diagnosis and treatment of diseases and other health conditions.
(Image: Photodisc)

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IAEA

The International Atomic Energy Agency's mission is to prevent the spread of nuclear weapons and to help all countries — especially in the developing world — benefit from the peaceful, safe and secure use of nuclear science and technology.

Established as an autonomous organization under the United Nations in 1957, the IAEA is the only organization within the UN system with expertise in nuclear technologies. The IAEA's unique specialist laboratories help transfer knowledge and expertise to IAEA Member States in areas such as human health, food, water and the environment.

The IAEA also serves as the global platform for strengthening nuclear security. The IAEA has established the Nuclear Security Series of international consensus guidance publications on nuclear security. The IAEA's work also focuses on helping to minimize the risk of nuclear and other radioactive material falling into the hands of terrorists, or of nuclear facilities being subjected to malicious acts.

The IAEA safety standards provide a system of fundamental safety principles and reflect an international consensus on what constitutes a high level of safety for protecting people and the environment from the harmful effects of ionizing radiation. The IAEA safety standards have been developed for all types of nuclear facilities and activities that serve peaceful purposes, as well as for protective actions to reduce existing radiation risks.

The IAEA also verifies through its inspection system that Member States comply with their commitments under the Nuclear Non-Proliferation Treaty and other non-proliferation agreements to use nuclear material and facilities only for peaceful purposes.

The IAEA's work is multi-faceted and engages a wide variety of partners at the national, regional and international levels. IAEA programmes and budgets are set through decisions of its policymaking bodies — the 35-member Board of Governors and the General Conference of all Member States.

The IAEA is headquartered at the Vienna International Centre. Field and liaison offices are located in Geneva, New York, Tokyo and Toronto. The IAEA operates scientific laboratories in Monaco, Seibersdorf and Vienna. In addition, the IAEA supports and provides funding to the Abdus Salam International Centre for Theoretical Physics, in Trieste, Italy.

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IAEA Bulletin 55-4-December 2014

IMPROVING PUBLIC HEALTH WITH RADIATION MEDICINE AND TECHNOLOGY

Non-communicable diseases such as cancer and cardiovascular disorders are becoming increasingly common throughout the world, including in low and middle income countries.

The growth in the number of people with such conditions is putting an enormous strain on developing countries, which often lack the resources to diagnose and treat these conditions effectively. Many people die of diseases which would be treatable if they lived in countries with advanced health care systems. This is a great human tragedy.

The IAEA plays an important role in ensuring that the highest safety standards are maintained when radiation techniques are used. This involves protecting both staff involved in administering procedures from exposure to radioactivity, and ensuring that patients receive the correct dose.

This edition of the IAEA Bulletin provides an insight into what the IAEA is doing to help.

As far as cancer is concerned, we help countries to establish or upgrade oncology and radiotherapy centres, and to build capacity in nuclear medicine for diagnosis.

We help to ensure that medical and technical staff receive the training they need to do their work effectively. And we work with countries to ensure that radiotherapy services are integrated within a comprehensive, sustainable cancer control programme.

This is very important work. Action to fight cancer is urgently needed. By 2020, it is estimated that over 10 million people will die of the disease each year.

The IAEA has been working to deploy radiotherapy and nuclear medicine programmes in around 130 low and middle income countries. In the past eight years alone, we sent specialist teams to assess cancer control capacity in over 65 Member States.

Progress has been made in cancer control in many developing countries in recent decades. But the challenges remain formidable. Around 5000 radiotherapy machines are still required to provide curative and palliative treatment for cancer patients in low and middle income countries. Such treatment is vital, both to bring about cures, wherever possible, and to provide pain relief. The IAEA has been developing initiatives to address this issue.

To ensure that radiotherapy facilities already in place are providing the best treatment and care possible, our Division of Human Health provides comprehensive audits of radiotherapy practices. These audits help to give Member States the confidence that their facilities are providing the best treatment possible. The IAEA also assists Member States in addressing the risk of medical isotope shortage that has emerged over the past years.

For other health conditions, such as cardiac diseases, radiation medicine in general, and radiology and nuclear medicine in particular, play an extremely important role in patient care.

Radiation medicine enables doctors to observe physiological functions and metabolic activity inside the human body and to learn more about the health of individual organs.

The IAEA plays an important role in ensuring that the highest safety standards are maintained when radiation techniques are used. This involves protecting both staff involved in administering procedures from

Top: During an official visit to Costa Rica in 2013, Director General Amano is briefed on the work of the Centre for Radiotherapy of the Mexico Hospital.

Below: Director General Amano is shown the equipment available at the Centre for Nuclear Medicine and Oncology at Bach Mai Hospital in Viet Nam during an official visit in 2014.

(Photos: C. Brady/IAEA)

exposure to radioactivity, and ensuring that patients receive the correct dose.

The IAEA works closely with partners such as the World Health Organization to strengthen the capacity of developing countries to diagnose and treat non-communicable diseases. Training and mentoring networks and innovative public–private partnerships play an important role.

We support a holistic approach to public health with the goal of ensuring that low and middle income countries, in particular, can establish comprehensive health care systems, with trained staff and adequate equipment, to provide early detection, timely diagnosis and effective treatment for non-communicable diseases, as well as palliative care.

Strengthening the IAEA's human health activities is a high priority for me as Director General. The IAEA remains committed to doing all it can to reduce the suffering caused by cancer and other non-communicable diseases.

Yukiya Amano, IAEA Director General

RADIATION AND RADIONUCLIDES IN MEDICINE

A Brief Overview of Nuclear Medicine and Radiotherapy

With the discovery of radiation and radionuclides for use in medicine, doctors now have more diverse and effective prevention, diagnostic and treatment options to offer their patients.

(Photo: D. Calma/IAEA)

In the past two centuries, the field of medicine has seen unprecedented advances. Alongside discoveries like the smallpox vaccine and antibiotics, the discovery of radiation and radionuclides for use in medicine has led to more diverse and effective prevention, diagnostic and treatment options for many health conditions.

Diseases like cancer that were once considered unmanageable and fatal can now be diagnosed earlier and treated more effectively using nuclear techniques, giving patients a fighting chance and, for many, a significant chance for a cure. These methods are more important than ever as high-mortality diseases like cancer or cardiovascular diseases are on the rise and are among the leading health threats globally.

The IAEA has worked for over 50 years to promote the use of nuclear techniques in medicine by collaborating with its Member States and other organizations through projects, programmes and agreements. The Agency's aim is to help build Member States' capacities in this field in order to support the provision of high-quality health care worldwide, particularly in developing countries. Since the IAEA began its work in human health, the use of nuclear techniques in medicine has become one of the most widespread peaceful applications of atomic energy.

The December issue of the IAEA Bulletin focuses on the work of the IAEA in the area of radiation medicine and technology. Before delving into this month's issue, here is an overview of the issue's two main themes: nuclear medicine and radiotherapy.

Nuclear Medicine

Nuclear medicine is a field of medicine that uses a trace amount of radioactive substances called radioisotopes for the diagnosis and treatment of many health conditions such as certain types of cancer, and neurological and heart diseases.

Diagnostic Techniques in Nuclear Medicine

In nuclear medicine, radionuclides are used to provide diagnostic information about the body. The techniques in this field can be broadly divided into two categories: in vitro and in vivo procedures.

A gamma camera traces and detects radiopharmaceuticals inside of a patient in order to produce diagnostic images.

(Photo: E. Estrada Lobato/IAEA)

In vitro

In vitro diagnostics procedures are performed outside of the body, such as in a test tube or culture dish. Within the field of nuclear medicine, procedures, such as radioimmunoassay or immunoradiometric assay, primarily focus on identifying predispositions to certain health conditions and early diagnosis using genotyping and molecular profiling for a variety of conditions. This can range from identifying changes in cancer cells and tumour makers, to measuring and tracking hormones, vitamins and drugs for detecting nutritional and endocrinological disorders as well as bacterial and parasitical infections such as tuberculosis and malaria.

In vivo

In vivo non-invasive procedures take place inside the body and are the majority of those done in nuclear medicine. These methods involve using radiopharmaceuticals, which are carefully chosen radioactive materials, that are absorbed into a patient's body and, due to their specific chemical properties, target specific tissues and organs, such as the lungs or the heart, without disturbing or damaging them. The material is then identified by using a special detector, such as a gamma camera, placed outside of the body that is able to detect the small amounts of radiation released from the material. The camera is then able to translate the information into two-dimensional or three-dimensional images of the specific tissue or organ.

Among the more well-known and the fastest growing of these techniques is positron emission tomography (PET). Doctors use special instruments called positron emission tomographs to produce scans in order to track body chemistry and organ function on a molecular level, which allows them to identify more nuanced changes in health in a patient at an earlier stage than many other diagnostic techniques. PET scans can be combined with other scanning techniques such as computed tomography to further enhance the speed, accuracy and usefulness of nuclear medical imaging.

Nuclear medicine techniques like these, unlike a traditional X-ray image which depicts anatomical details, reveal how the body functions: they show important dynamic physiological or biochemical qualities of the targeted body part. The information produced during such diagnostic procedures frequently supplements static X-ray images, helping a doctor to determine the status and function of different organs, which can be useful as a doctor makes critical decisions and tailors treatment to the patient's needs.

A radiation therapy machine delivers a beam of radiation in order to treat cancer in a patient.

(Photo: D. Calma/IAEA)

Radiation Therapy

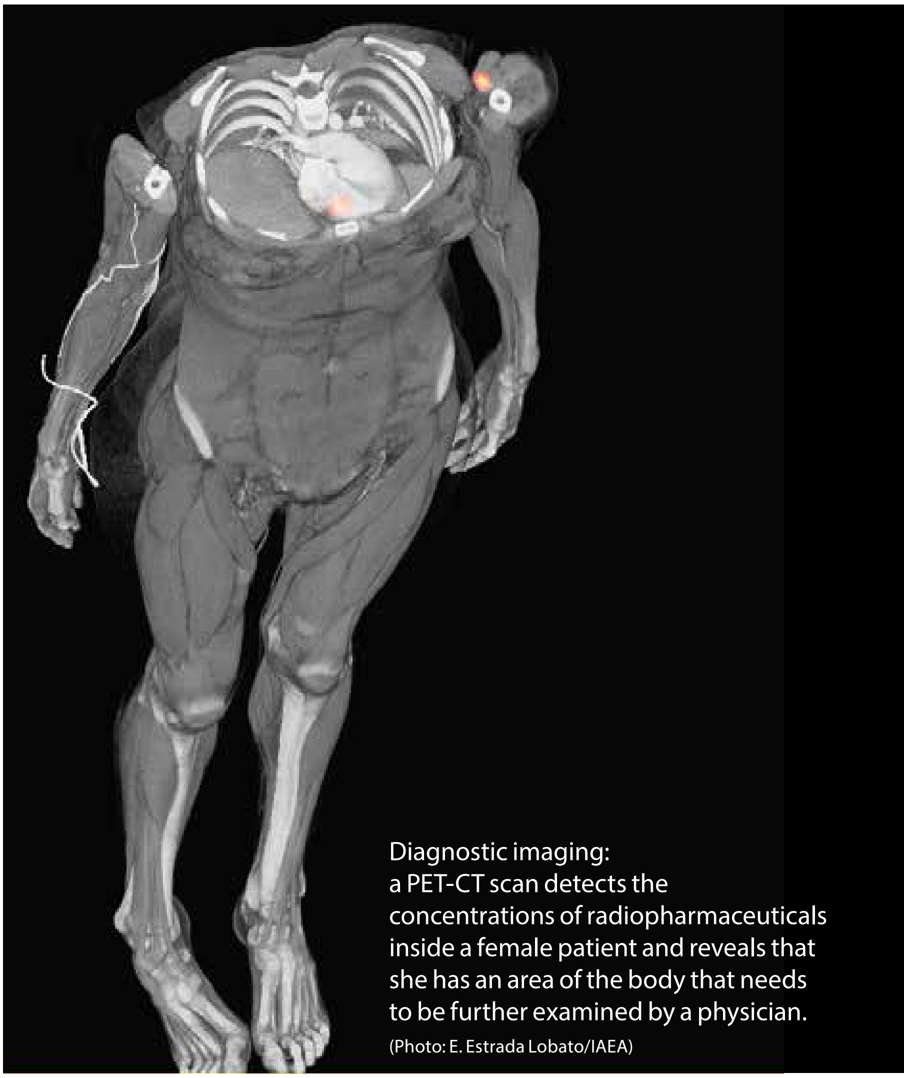
Radiation therapy, or radiotherapy, is a branch of medicine that focuses on the use of radiation to treat cancer. Radiotherapy is designed to use radiation to target and kill cells. In the case of cancer, when the radiation is applied to a cancerous tumour, or a mass of malignant cells, the targeted cells are damaged and killed, leading to a reduction of the tumour size or, in some cases, the disappearance of the mass.

There are primarily three types of radiation therapy treatment options: external beam radiation therapy, brachytherapy and systemic radioisotope therapy.

External beam radiation therapy delivers a beam, or multiple beams, of radiation to target specific areas of a patient's body. The beam is designed to minimize radiation exposure to healthy cells, while controlling or killing the cancer cells. The beams can consist of electrons and/or X-rays, gamma rays or, in the case of particle therapy, protons or carbon ions. In some cases, doctors also use these beams in conjunction with surgery where the surgical procedure is used to uncover the tumour in order to allow the beam to more directly target the mass. This type of procedure is called intraoperative radiation therapy.

Brachytherapy is the placement of radiation sources inside of or next to an area of a patient's body that requires treatment. For example, in the case of cervical cancer, radioactive sources can be placed directly into the uterus in order to target a cervical mass. Unlike external beam radiation, brachytherapy allows for a tumour to be treated with high doses of localized radiation, while reducing the probability of unnecessary exposure to surrounding healthy tissue.

Systemic radioisotope therapy (also known as radionuclide therapy) can be used to address a range of health conditions, such as cancer, blood disorders, or those affecting the thyroid gland. It involves small amounts of radioactive material, such as lutetium-177 or yttrium-90, taken into the body through a body cavity, intravenously, orally or other routes of administration that then target different body parts or organs for treatment. The radioactive material used for treatment is chosen for its isotope properties, or chemical properties, as certain body parts can absorb certain isotopes significantly more effectively than other body parts, which allows doctors to target those specific areas during treatment.



Diagnostic imaging:
a PET-CT scan detects the concentrations of radiopharmaceuticals inside a female patient and reveals that she has an area of the body that needs to be further examined by a physician.

(Photo: E. Estrada Lobato/IAEA)

For example, a patient with a thyroid condition may be treated with radioactive iodine, sodium-iodide-131, therapy. This involves the patient swallowing a small amount of sodium-iodide-131, which is then absorbed into the bloodstream through the gastrointestinal tract and later concentrates in the thyroid gland, which absorbs iodine-131 thousands of times more than the rest of the body. Once in the thyroid gland, iodine-131 begins to destroy highly-active cancer cells in the gland, thus removing those cells causing the health condition.

Nicole Jawerth, IAEA Office of Public Information and Communication

SEVEN THINGS TO KNOW ABOUT RADIOISOTOPES

1. What are radioisotopes?

Each atomic element knows exactly how many protons and neutrons it needs at its centre (nucleus) in order to be stable (stay in its elemental form). Radioisotopes are atomic elements that do not have the correct proton to neutron ratio to remain stable. With an unbalanced number of protons and neutrons, energy is given off by the atom in an attempt to become stable[1].

For example, a stable carbon atom has six protons and six neutrons. Whereas its unstable (and therefore radioactive) isotope carbon-14, has six protons and eight neutrons. Carbon-14 and all other unstable elements are called radioisotopes.

This movement towards stability, which involves emitting energy from the atom in the form of radiation, is known as radioactive decay.

This radiation can be tracked and measured, making radioisotopes very useful in industry, agriculture and medicine.

2. Where do radioisotopes come from? How are they made?

There are both naturally occurring and man-made radioisotopes. But for medical purposes, we only use the ones made by nuclear reactors and cyclotrons[2] because they are easy to produce, have the characteristics needed for imaging and typically have much shorter half-lives than their naturally occurring cousins.

Half-life is the amount of time it takes for half of the radioisotope to decay to half of its original activity, which tells us how long the radioisotope will remain. The very long half-lived radioisotopes are more stable and are therefore less radioactive. The half-lives of radioisotopes used in medicine range from a few minutes to a few days.

For example, rubidium-82, which is used for myocardial perfusion imaging has a half-life of 1.26 minutes, while iodine-131, used in thyroid treatment and diagnosis, has a half-life of eight days. Overall, there are about 1800 radioisotopes, and approximately 50 are being used in medicine.

3. How do we use radioisotopes in medicine?

Some radioisotopes give off alpha or beta radiation, and these are used for treating diseases such as cancer.

Others give off gamma and/or positron radiation, which is used in conjunction with powerful medical scanners and cameras* to take images of processes and structures inside the body, and for disease diagnosis. Radioisotopes have various uses in hospital (clinical) settings. They are used to treat thyroid diseases and arthritis, to relieve arthritic pain and pain associated with bone cancer, and to treat liver tumours. In cancer brachytherapy, a form of internal radiation therapy, radioisotopes are used to treat prostate, breast, ocular and brain cancer. They are also effective for the diagnosis of coronary artery disease and heart muscle death.

In medicine, two of the most commonly used radioisotopes are technetium-99m and iodine-131. The gamma emitting technetium-99m is used to image the skeleton and heart muscle in particular, but also for imaging the brain, thyroid, lungs (perfusion and ventilation), liver, spleen, kidney (structure and filtration rate), gall bladder, bone marrow, salivary and lacrimal glands, heart blood pool, infection and numerous other specialized medical studies. Iodine-131 is widely used to treat over-functioning thyroid glands, thyroid cancer and in imaging the thyroid. It is a beta emitter, making it useful for therapy[3]. Radioisotopes are also used for medical research to study normal and abnormal functioning of organ systems. It can also help in drug development research.

**These powerful imaging devices include single photon emission computed tomography and positron emission tomography cameras, which are often used with computed tomography scanners and magnetic resonance imaging.*

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[1] Stable isotopes exist as well, but they are beyond the scope of this article.

[2] A cyclotron is a complex machine that accelerates charged particles in a vacuum outwards from the centre along a spiral path. During the acceleration process, charged particles gain significant energy. The energized charged particles then interact with stable material that is placed in their path. The interaction transforms stable materials into medically useful radioisotopes that are used to make radiopharmaceuticals.

[3] World Nuclear Association | Radioisotopes in Medicine www.world-nuclear.org/info/Non-Power-Nuclear-Applications/Radioisotopes/Radioisotopes-in-Medicine

4. Why do we use radioisotopes in medicine? What's so special about them?

Radioisotopes are special because certain organs in the body respond in unique ways to different substances. For example, the thyroid absorbs iodine, more so than any other chemical, so the radioisotope iodine-131 is widely used to treat thyroid cancer and in imaging the thyroid. Similarly, specific radioactive chemicals are picked up and metabolized by other organs like the liver, kidney and brain. But most radioisotopes need to piggyback on something else (a biologically active molecule) to get to the desired organ. For example, technetium-99m is often tagged to six methoxyisobutylisonitrile molecules to get to heart tissues for the diagnosis of cardiac disorders.

Formulations of radioisotopes tagged molecules (called radiopharma-ceuticals) are inhaled, ingested or injected to help physicians measure organ size and function, identify abnormalities, and target treatment to a particular area.

Radioisotopes are also special because their use provides patients and doctors with the option of using minimally-invasive surgical techniques, rather than the far more risky large-scale surgeries, from which it is harder to recover, that were used in the past to treat most conditions. Radioisotopes allow targeted treatment to all visible and invisible sites of disease in the body.

5. Are radioisotopes dangerous to patients?

The radioisotopes given to patients undergoing diagnosis or treatment decay and quickly become stable (non-radioactive) elements within minutes or hours depending on their half-lives or they are rapidly eliminated from the body.

Doctors choose to use radioisotopes that have the appropriate half-lives and energy in order to get the best treatment, diagnosis or information possible without any harm to normal organ tissue. For example, technetium-99m has a half-life of six hours and gives off 140 keV (kiloelectronvolts) of energy, which is quite low and not enough to harm patients.

Doctors are also very careful about the amount of radioisotopes given to patients to minimize radiation dose while ensuring images of acceptable quality.

Short-lived and very short-lived radioisotopes are used in order to minimize the already small radiation dose the patient receives from the use of radiopharmaceuticals.

6. Are radioisotopes inside a patient dangerous to the public?

Medical staff follow strict rules and are trained to ensure that those patients who are given therapeutic doses of radioisotopes (these are only used for cancer treatment and other kinds of therapy, **never** for diagnosis) are kept isolated in their hospital rooms until the patient's exposure to the worker and public is reduced to a safe level. The nurses, doctors and porters charged with their care also maintain a safe distance during any interaction and wear personal dosimeters that keep track of their radiation doses at work to ensure that their doses do not exceed a specified limit, which is far below the safety threshold.

As soon as the radioisotopes decay to a level where the radiation exposure is low enough, the patients are free to go about their normal lives and return to their normal routines.

7. If medical staff are cautioned to keep a distance, then why are these treatments allowed for patients?

Patients benefit from the properties of radiation in the treatment of cancer. Those who need the procedure are justified in having the procedure. It all relates to 'justification', a key concept in nuclear medicine. Justification means that the benefit derived from the use of radiation must outweigh the potential harm to the patient. And for someone who has cancer, the use of a short lived radioisotope during treatment could cure them from the cancer or extend their lives. Health care workers are trained on clinical practices to appropriately manage exposure as they provide support for patients undergoing radiation therapy. Therefore these treatments are often justified in the eyes of both the patient and their physician.

Sasha Henriques, IAEA Office of Public Information and Communication

WHAT LIES WITHIN

Using Radiopharmaceuticals to Reveal and Target Diseases Hidden Inside the Human Body

A worker looks inside of a shielded container as she prepares radiopharmaceuticals to be packaged into glass vials.
(Photo: D. Calma/IAEA)

The ability to pinpoint the location and size of a cancerous mass hidden inside of a patient's body was unthinkable less than 100 years ago. Today, with the help of special scanning machines, doctors are able to use radioactive drugs known as radiopharmaceuticals to get a glimpse inside the human body, and these pharmaceuticals can even be used in treating many health conditions. In nuclear medicine, radiopharmaceuticals play an essential role for minimally invasive diagnostic, treatment and care management procedures for many diseases, especially cancer, as well as for relieving pain associated with certain cancers.

Inside Radiopharmaceuticals

Radiopharmaceuticals are drugs that contain radioactive substances called radioisotopes. Radioisotopes are atoms that emit radiation as gamma rays or particles. In some cases, radiopharmaceuticals use radioisotopes that emit a combination of these types of radiation.

The radioisotopes used in radiopharmaceuticals can be produced by irradiating a specific target inside of a nuclear research reactor or in particle accelerators, such as cyclotrons[1]. Once produced, the radioisotopes are tagged on to certain molecules based on biological characteristics, which then results in radiopharmaceuticals.

How Radiopharmaceuticals Work and are used in Medicine

When a doctor decides to use radiopharmaceuticals in a patient for diagnostic and/or

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[1] A cyclotron is a complex machine that accelerates charged particles in a vacuum outwards from the centre along a spiral path. During the acceleration process, charged particles gain significant energy. The energized charged particles then interact with stable material that is placed in their path. The interaction transforms stable materials into medically useful radioisotopes that are used to make radiopharmaceuticals.

treatment purposes, the drugs are generally delivered through an injection, orally or introduced in a body cavity. Once inside the body, the different physical characteristics and biological properties of radiopharmaceuticals causes them to interact with or bind to different proteins or sugars inside the body. This in turn means that the drugs tend to concentrate more in specific body parts depending on that area's biological characteristics. Therefore, doctors are able to precisely target areas of the body by selecting specific types of radiopharmaceuticals.

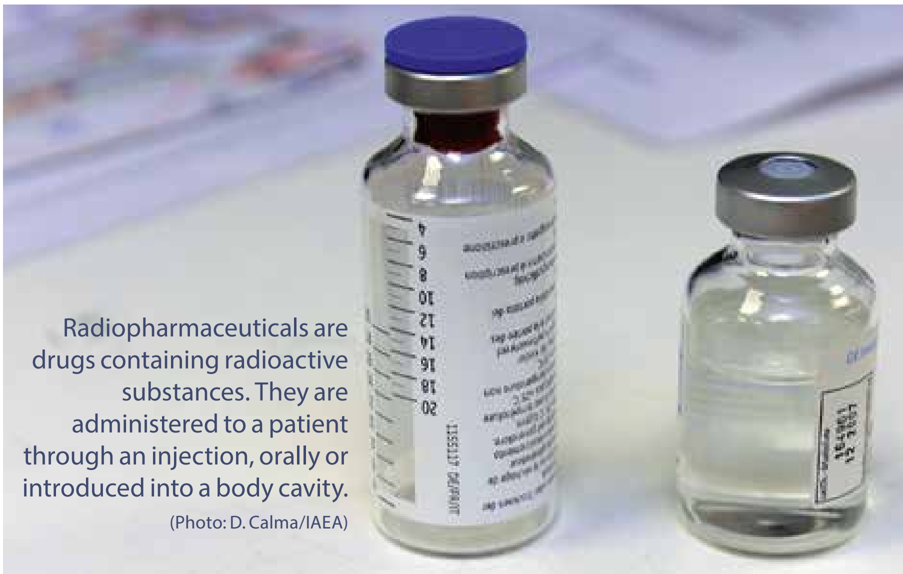
For example, there are currently several radiopharmaceuticals that accumulate preferentially in cancerous tissues making those radiopharmaceuticals effective tools for diagnosing and treating certain types of cancer. This is similarly the case for other radiopharmaceuticals.

Within a few hours to a few days, the radiopharmaceutical dissipates to undetectable levels and/or is eliminated and is no longer found in the body.

For Diagnostic Imaging

When radiopharmaceuticals are used for diagnostic imaging, a doctor will select a radiopharmaceutical containing a radioisotope that emits gamma rays or a particle radiation called positrons, which can be detected using a gamma camera or scanners. These machines can detect where the radiopharmaceutical is concentrating and emitting radiation, translating that information into two- or three-dimensional images that highlight the location and size of the organ or tissue of interest, including cancerous lesions. Diagnostic imaging is widely and routinely used in cardiology and for thyroid disorders, and many other parts of the body (such as the liver, kidneys, brain, skeleton and so on) are also examined using diagnostic radiopharmaceuticals.

In addition to gathering precise information on the size, shape and location of various organs and tumors, radiopharmaceuticals and diagnostic imaging are also used to obtain functional information of various systems in our body. For example, cardiac imaging is used to assess the heart's functions and capacities, to see how blood pumps through the heart, and to examine the heart for any dead or damaged tissue. It is the most commonly used diagnostic test to help cardiac patients receive suitable treatment in a timely manner and to periodically follow up on their health. In the case of cancer patients, imaging is periodically done to assess how the cancer is responding to treatment and to watch over the patient to catch any recurring cancer in order to deliver timely treatment to prevent it from developing further.



Radiopharmaceuticals are drugs containing radioactive substances. They are administered to a patient through an injection, orally or introduced into a body cavity.

(Photo: D. Calma/IAEA)

Radiopharmaceuticals used for diagnostic imaging emit small amounts of radiation which are considered a net benefit to the patient. The two imaging technologies primarily used with radiopharmaceuticals are the single photon emission computed tomography (SPECT) scanner for detecting gamma rays, and the positron emission tomography (PET) scanner for detecting positrons. When PET and/or SPECT scanners are used in combination with traditional computed tomography, another type of scanning technology, the radiation emitted from the radiopharmaceuticals can be detected to pinpoint accuracy.

The most commonly used radiopharmaceutical for SPECT contains technetium-99m. It is used in more than 80 per cent of all diagnostic procedures in nuclear medicine and is most often used for cardiac and bone scans. Technetium-99m is produced from its parent radioisotope molybdenum-99 through a generator system. Technetium-99m can be tagged to various molecules to produce a number of radiopharmaceuticals designed to target specific organs or diseases.

For PET, the most widely used radiopharmaceutical is fluorine-18 fluorodeoxyglucose (FDG), a glucose analogue that is more readily absorbed by very active cancer cells than by

Doctors administer a radiopharmaceutical to the patient, which is then detected by a scanning machine. The images produced by the scanner are then analysed by the doctors in order to determine the next course of action for the patient.
(Photo: E. Estrada Lobato/IAEA)

healthy cells, and that contains a radioisotope called fluorine-18. Fluorine-18 is produced by bombarding oxygen-18 with high energy protons in a cyclotron, a type of particle accelerator. Fluorine-18 is then tagged to various molecules to produce a number of organ and disease specific PET radiopharmaceuticals.

For Therapeutic Applications

After an illness has been diagnosed, radiopharmaceutical therapy in some cases may be the best course of treatment. Therapeutic radiopharmaceuticals are chosen by doctors because the drugs contain radioisotopes that emit particle radiation that is powerful enough to destroy diseased cells.

The radiation released from a radiopharmaceutical is detected by a specialized machine, which is able to produce images similar to this. This diagnostic image shows the results of a SPECT-CT scan of a female patient that is suffering from a severe inflammation of the left hip due to sclerosis.
(Photo: E. Estrada Lobato/IAEA)

Radiopharmaceutical therapy for managing and treating diseases relies on how effectively the radiopharmaceutical can localize in the tissue or organ to be treated, which in turn depends on how the body interacts with the radiopharmaceutical. Once selected, radiopharmaceuticals are administered in larger doses in order to deliver targeted doses of radiation to problematic areas within the body.

For example, radioactive sodium-iodide-131 in the form of iodine, is a radiopharmaceutical commonly used in the treatment of thyroid cancer as scientists have found that nearly all iodine from the blood accumulates in the thyroid. This means that when a doctor administers a dose of sodium-iodide-131, the thyroid almost exclusively absorbs the drug, leaving the rest of the body virtually unaffected. Once absorbed into the thyroid, the high dose of radioactive iodine releases radiation that destroys the cells of the gland and in turn the cancer cells. There is no conventional treatment that can replace the use of sodium-iodide-131 for the treatment of thyroid cancers or hyperactive thyroid.

Similarly, radium-223, another particle radiation emitter, is successfully used in the form of radium chloride to treat patients with bone cancers due to advanced prostate cancer, which results in improved survival rates.

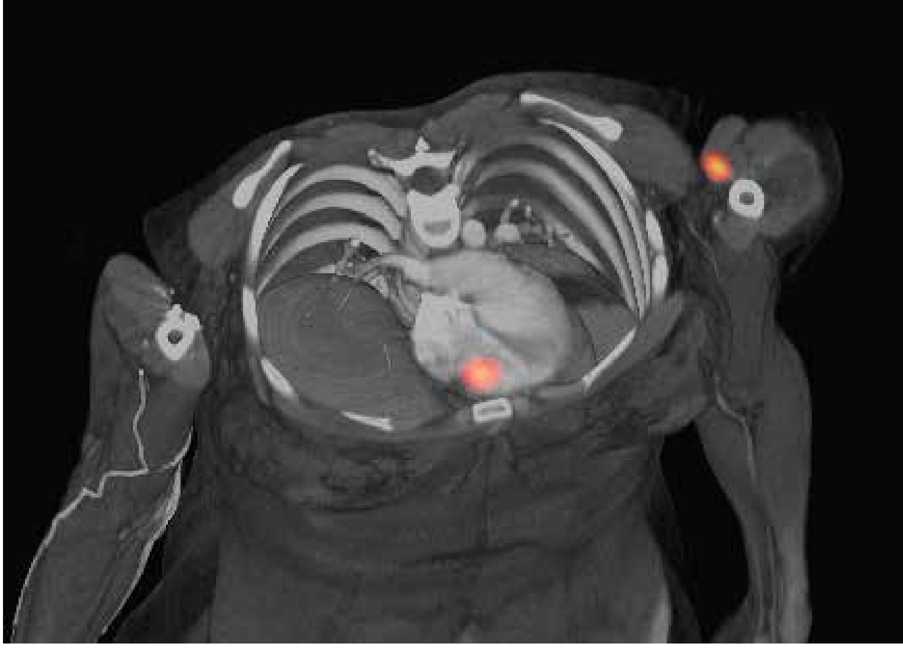
The IAEA and Radiopharmacy

Through projects, programmes and agreements, the IAEA supports its Member States in developing their capacities in the area of radiopharmacy. The IAEA assists with human resources development such as fellowships and expert visits, and provides equipment, technology transfer, training courses and educational tools. The IAEA has also developed guidance documents that detail requirements for establishing radiopharmaceutical production facilities that are safe and reliable. The aim of these activities is to help to ensure that radiopharmaceuticals consistently meet required quality standards for providing reliable and safe nuclear medicine practices.

Research and Development: Through IAEA coordinated research projects (CRPs), Member States are able to further their research and development of radiopharmaceuticals and focus on topics that experts have identified as beneficial. This can help to foster scientific and technical knowledge exchanges as well as stimulate progress in radiopharmacy and, more broadly, nuclear technology and applications.

For example, a CRP on sentinel node imaging has led to a newly developed radiopharmaceutical that has proven to be very effective in tracing the spread of cancer through the lymphatic system. Similarly, a CRP on new radiopharmaceuticals of fluorine-18 and gallium-68 has facilitated collaborative efforts between centres of excellence and centres that are developing such radiopharmaceuticals for the first time. These examples highlight the types of results that can stem from CRPs.

Capacity Building: A major area of the IAEA's focus is helping to build Member State capacities in many nuclear-related areas. Through the IAEA's technical cooperation (TC) projects, Member States receive expert support for developing their abilities to use nuclear tools, such as radiopharmaceuticals. A recent example is a TC project on establishing a major training programme based on e-learning methods for radiopharmacy technologists and radiopharmacists via coordinating academic institutions and professional scientific organizations.

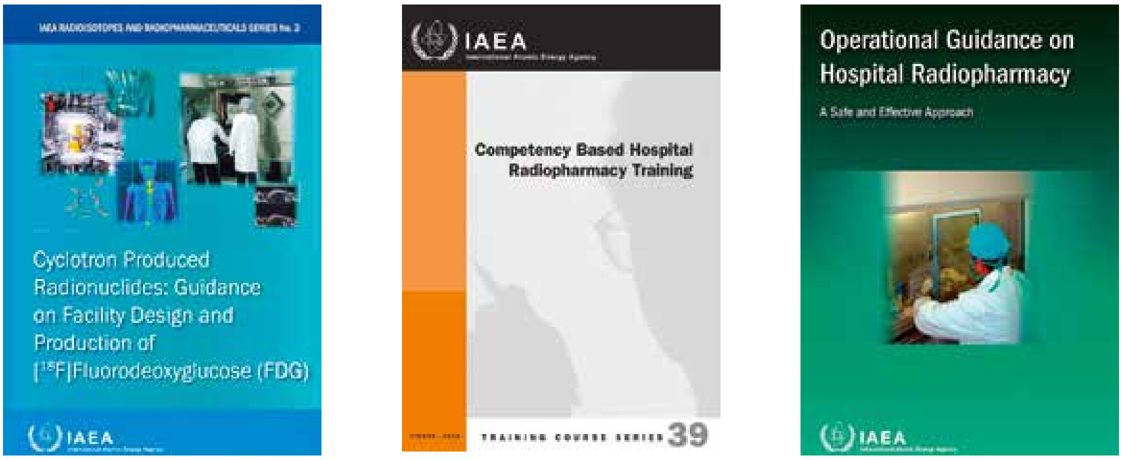


After a radiopharmaceutical is administered to the patient, a PET-CT scan detects the radiation released from the drug and the resulting diagnostic image shows that the male patient suffers from lung cancer and metastases to the lymph node near the heart.

(Photo: E. Estrada Lobato/IAEA)

Safety Standards: For the IAEA, the safety of patients, staff, members of the public and the environment is of the utmost importance. The IAEA has produced several publications and guidelines for Member States that are working in the area of radiopharmacy. The aim is to provide Member States with safety standards guidelines for ensuring the safety, quality and efficacy of radiopharmaceuticals.

Nicole Jawerth, IAEA Office of Public Information and Communication in collaboration with the Radioisotope Products and Radiation Technology Section, IAEA Department of Nuclear Sciences and Applications



The IAEA produces publications and guidelines related to radiopharmacy.

GETTING A CLEAR PICTURE ON MEDICAL IMAGING

Diseases take on all shapes and forms, and some are easier to detect than others. Obvious outward growths like rashes and warts are quick to spot, but for some diseases and conditions more information is needed. Fortunately, nuclear medicine doctors today can use a wide range of modern imaging and diagnosis techniques and technologies to identify a variety of health conditions.

SPECT, PET, MRI, CT, ECHO, fluoroscopy — the list of diagnosis techniques go on, but do you know what they actually are?

Imaging techniques can be broken down into two basic categories: those that simply show the anatomy, known as radiology, and those that look at the physiology, on how the body functions, which is known as functional imaging. This article presents a breakdown of the two imaging disciplines and how some of the most common techniques work.

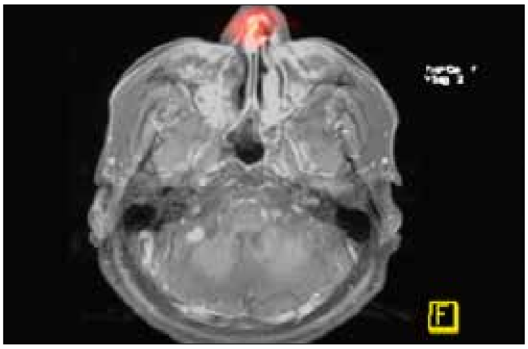
Radiology

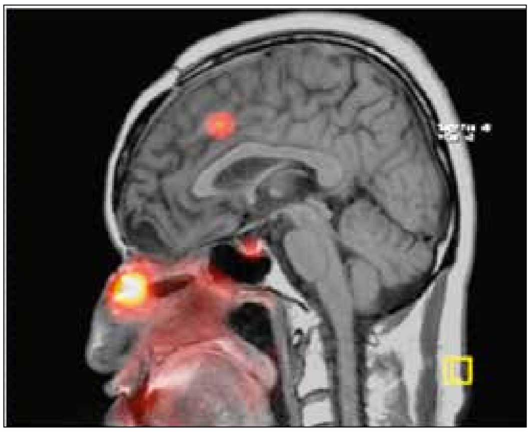
X-ray radiography

This is probably the imaging technology most people are familiar with. It works in a similar manner to casting a shadow; a patient's body part (a broken arm, for example) is placed in front of an X-ray detector and illuminated by an X-ray generator. As X-rays pass through the patient, the rays are absorbed depending on the density and composition of the body part. Bones and flesh do not absorb X-rays at the same efficiency. Some of the rays go through to the X-ray detector and help create an image. The imaging technique in which X-rays produce real-time images and video is called fluoroscopy.

MRI

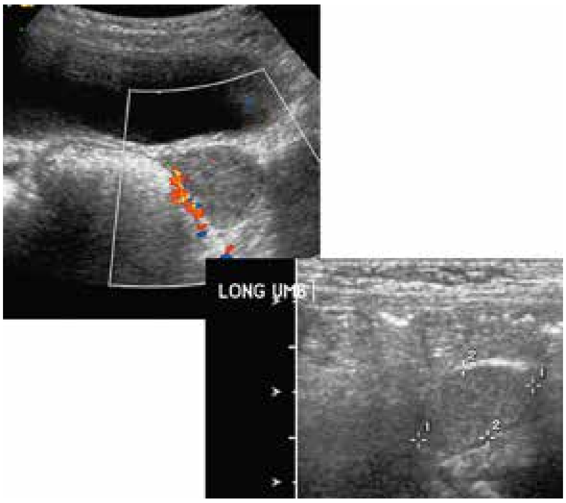
Magnetic resonance imaging produces an image by using a very powerful magnet. The magnet creates a magnetic pulse that aligns water molecules in the patient's body. When the pulse stops, the molecules relax and revert back to their previous state, which in turn produces a signal that is detected without ionizing radiation. Highly-sensitive instruments detect the signal and the resulting information can be translated into an image. Changing the strength and angle of the magnetic fields shows differences between tissue types, allowing doctors to visualize tissues normally too soft to detect through other means.





ECHO

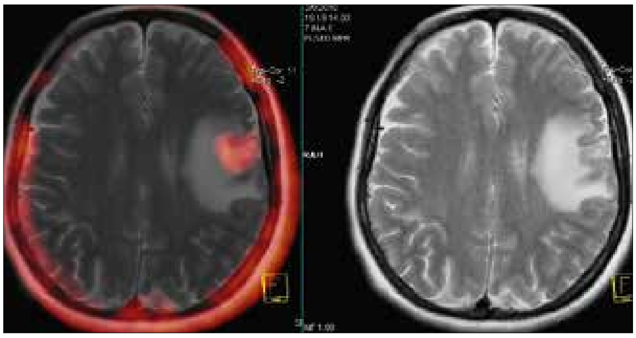
An echocardiogram is a sonogram or ultrasound image of a heart and involves no ionizing radiation. An ultrasound signal (a sound wave with a frequency above the upper limits of human hearing) is directed to the heart and as it bounces back after encountering tissue or bone, it is picked up by a sensor. Depending on the frequency of the sound and the time it takes to return, it is possible to create an image of the patient's heart.



Functional Imaging

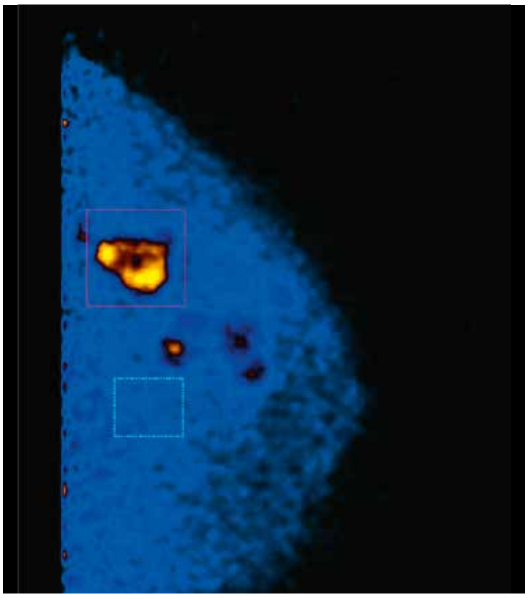
SPECT

Single photon emission computed tomography is an imaging technique which uses a rotating camera to detect gamma rays released by a gamma emitting radioisotope that is injected into the patient's veins. Different radioisotopes localize in specific organs or areas in the body and reveal the shape or function of the target area to the camera, which is then reconstructed into an image by a computer. The radioisotopes used have short half-lives and so they do not stay in the body for long.



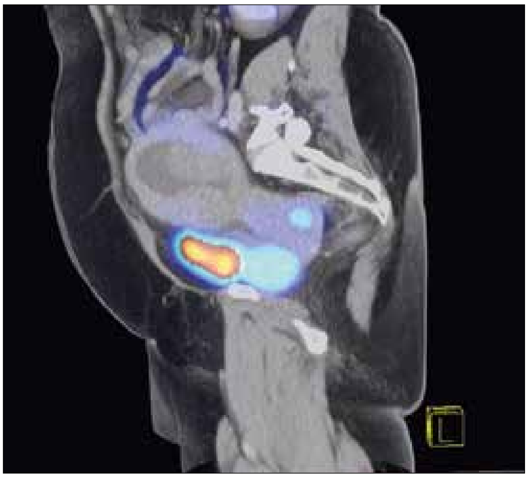
PET

Positron emission tomography works in the same way as SPECT, but uses radioisotopes that decay even faster and produce two gamma rays that move in opposite directions. This allows views from multiple angles, making it possible to produce a three-dimensional visualization of the target area or organ.



CT

X-ray computed tomography creates an image by rotating an X-ray emitting source and an opposing sensor around a patient. As the X-rays pass through the patient they are deflected and changed. These minute changes are detected by the sensor and translated into an image. The resulting images are cross-sectional 'slices' of a patient, allowing doctors to create three-dimensional reconstructions of patients and their insides.



Michael Amdi Madsen, IAEA Office of Public Information and Communication
(Images: E. Estrada Lobato/IAEA)

ENSURING THE SAFETY AND ACCURACY OF RADIATION MEDICINE

The Role of Medical Physicists

A physicist prepares a head phantom, which is a model of a head, for output measurements from a diagnostic imaging machine.

(Photo: D. Calma/IAEA)

In nuclear medicine and radiology, what are the risks of carrying out a procedure without the presence of a qualified medical physicist and without adequate guidelines?

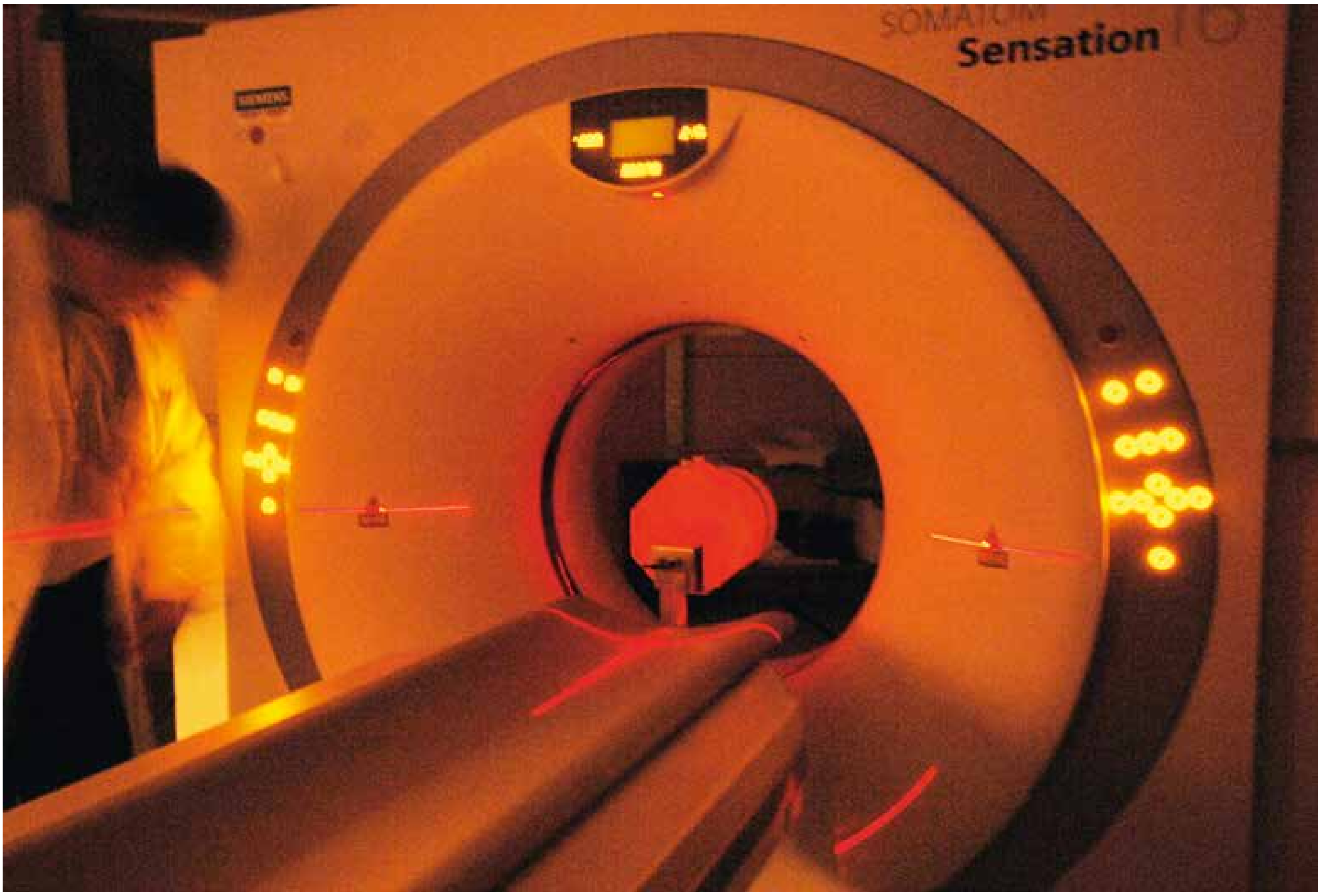
- The patient may receive an incorrect dose which can jeopardize the success of the medical treatment or the quality of diagnosis;
- The medical staff and the public might be in danger of radiation exposure;
- In extreme cases, the procedure could lead to a serious accident.

Globally, over 10 000 hospitals use radioisotopes in medicine, with almost 90 per cent for diagnostic procedures. Nuclear medicine technologies, both for treatment and diagnostic imaging for diseases such as cancer or cardiovascular diseases, are being constantly developed and deployed globally in health care systems.

Imaging procedures, such as hybrid imaging with positron emission tomography/computed tomography (PET/CT) which is a combination of technologies from nuclear medicine and radiology, allow better detection and staging of diseases by displaying functional and anatomical information, facilitating accurate diagnosis and swift treatment. However, the use of radiation in imaging and treatment can only be optimized and made effective if health care systems have skilled professionals who possess the knowledge and expertise to ensure that applications of radiation for medical purposes is effective and safe, with no potential overexposure.

This is exactly the role of medical physicists. Medical physicists are health professionals with specialized education and training in the concepts and techniques of applying physics in medicine while ensuring that radiation protection procedures are rigorously followed during diagnosis and treatment. At the same time, they ensure the accurate use of specific tools and specialized instrumentation in all disciplines of radiation medicine. They are part of a multidisciplinary team involved in the diagnosis and treatment of patients with ionizing and non-ionizing radiation, and contribute to ensure a high standard of quality of service in hospitals and clinics.

Medical physicists play a vital role in health care systems. In addition to the core tasks related



A head phantom, which is a model of a head, is used by physicists to align the gantry of a diagnostic scanning machine.

(Photo: D. Calma/IAEA)

to patient care, they also undertake critical tasks related to technical procedures which contribute to patient and staff safety, and also to the cost-effective operation of a radiation facility. These procedures include:

- Defining the technical specifications of new equipment to reflect a facility's clinical requirements and ensure that the newly installed equipment operates as specified throughout its expected life;
- Ensuring compliance with regulatory requirements;
- Developing and establishing quality management systems on the use of radiation sources for medical treatment and applying specialized tools for quality control;
- Collaborating with other clinical professionals for the commissioning and supervision of the implementation of new or complex clinical procedures;
- Training the staff associated with radiation protection issues to ensure that safe and correct procedures are performed.

Medical physicists play a significant role in the mandate that arises from Article II of the IAEA's Statute: "The Agency shall seek to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world." The IAEA has a long history of supporting medical physics both indirectly, through the publication of guidance documents, and directly, through its technical cooperation programme, which creates awareness and supports capacity building related to medical physics in Member States.

The application of ionizing radiation for medical purposes has been well established and justified for decades, but it does involve risks. With the patient being the central point of any medical diagnosis and treatment procedure, the safe and efficient use of radiation requires trained medical professionals, such as medical physicists, in order to provide swift diagnosis and treatment, and to contribute effectively to a country's health care system.

Aabha Dixit, IAEA Office of Public Information and Communication

MODERNIZATION OF THE RADIOISOTOPES PRODUCTION

Incorporating advanced concepts of

1 A radioisotopes and radiopharmaceuticals production laboratory was established in Chile in the 1960s for research activities. From 1967 until January 2012, it was dedicated to the manufacturing of radioisotopes and radiopharmaceuticals for medical diagnosis and treatment purposes. In 2012, modernization of the facility's design and technology began as part of the IAEA technical cooperation project, Modernizing the Radioisotopes Production Laboratory of La Reina Nuclear Centre by Incorporating Advanced Concepts of Safety and Good Manufacturing Practices, (CHI4022).

2 The laboratory's modernization was justified by the need to improve radiation protection structures and pharmaceutical grade cleanliness and to be compliant with nuclear and health regulations. This included renovating the small lead glass windows, the old telemanipulators (hand-like mechanisms for remote handling of hazardous radioactive materials by workers) and the laboratory's eight hot cells. Hot cells are shielded containment chambers designed to protect workers as they work with radioactive materials. It is essential that the cells are well-constructed to ensure high safety standards.

3 The building was partially demolished in order to build new walls and slab reinforcements that can support the weight of the new hot cells. A specialist company was hired to construct the concrete pillars. This stage of construction also included the assembly of the supporting structure for lead bricks.

4 The supporting structure for the hot cells was made from steel plates welded and bolted together and anchored to the floor. The inner and outer walls of the hot cells were constructed from lead bricks. Lead is a preferred material for the construction of hot cells because lead has a high density and is able to block harmful radiation.

LABORATORY OF THE LA REINA NUCLEAR CENTER IN CHILE

safety and good manufacturing practices

5 The hot cells for producing technetium-99m and iodine-131 radiopharmaceuticals were constructed with lead glass windows and interlocking frames for mounting the telemanipulators. The IAEA supplied the lead glass windows and telemanipulators, which were installed by technicians who worked alongside staff from the Chilean Nuclear Energy Commission (CCHEN).

6 Lead walls and lead doors were installed to ensure that the ‘hot zone’ of the facility, the area where radioactive materials are present, was safe and secure. The ‘hot zone’ is also the area where raw radioactive materials are brought in and from which, after processing in hot cells, finished products (i.e. radiopharmaceuticals) are brought out.

7 The new hot cells for production of technetium-99m were in compliance with the relevant good manufacturing practice requirements. The exterior of the cell was made of stainless steel with the walls, floor and ceiling meeting required pharmaceutical cleanliness.

At the end of the corridor, a transfer hatch (window) connects to another laboratory where iodine-131 is produced.

8 A sophisticated ventilation system with pre-filters, high efficiency particulate air (HEPA) filters and active carbon filters were installed with the new hot cells and were designed with a double filter system to improve safety.

Text: Silvia Lagos Espinoza, CCHEN; Photos: CCHEN

RADIOPHARMACEUTICALS FOR COST EFFECTIVE MANAGEMENT OF CANCER

IAEA Deputy Director General and Head of the Department of Nuclear Sciences and Applications, Aldo Malavasi (left), and João Alberto Osso Junior, Head of the Radioisotope Products and Radiation Technology Section of the IAEA Division of Physical and Chemical Sciences (right), at the third Research Coordination Meeting on the Development of Gallium-68 based PET-Radiopharmaceuticals for Management of Cancer and Other Chronic Diseases.

(Photo: C. Gravino/AEA)

The search for swift and precise scientific procedures that can map the human body for exact diagnosis and rapid treatment for diseases like cancer has long been on the global agenda. Among the medical techniques developed is the unique application of nuclear technology using radiopharmaceuticals.

Radiopharmaceuticals are radiotracers used in small amounts for imaging organ functions and diagnosing diseases. The radiation a patient receives from them is very low, non-invasive and considered safe. Its emissions can be precisely detected, producing images useful for diagnostic purposes.

Imaging techniques, such as computed tomography (CT), magnetic resonance imaging (MRI) and ultrasonography, are capable of charting physiological function and metabolic activity. Radiopharmaceuticals, in comparison, can provide more specific and detailed information about organ function and metabolism.

Radiopharmaceuticals are commonly used with a well-established scanning device, such as positron emission tomography (PET). The conventional PET radiopharmaceuticals are mainly based on the radioisotope fluorine-18. However, the production of fluorine-18 requires a cyclotron[1] and associated facilities, which are quite expensive and time-consuming to set up. In contrast, another suitable radioisotope, gallium-68, is readily available through germanium-68/gallium-68 generators.

The gallium-68 radioisotope has favourable physical properties and is significantly cheaper than cyclotron-produced radioisotopes.

The IAEA is among the leading pioneers supporting the development of state-of-the-art nuclear technology in the use of radiopharmaceuticals. It hosted a Research Coordination Meeting at its headquarters from 1 to 5 September 2014 as part of an ongoing IAEA coordinated research project focusing on the development of gallium-68 radiopharmaceuticals. The meeting involved 17 institutions from across the world that are working to develop gallium-68 radiopharmaceuticals.

At this meeting, results from various countries were analysed and the work plan for the next period of the project was discussed. It was agreed to produce and test ready-to-use 'kit' chemical formulations with the gallium-68 radioisotope obtained from a germanium-68/gallium-68 generator.

In his welcome address, IAEA Deputy Director General and Head of the Department of Nuclear Sciences and Applications, Aldo Malavasi, highlighted the importance of gallium-68 radiopharmaceuticals as a diagnostic tool in nuclear medicine, and pointed out the relevance of the work performed by researchers in this field.

In particular, producing kits ready to be labelled with the radioisotope would facilitate its use in clinics, said Mr. Malavasi, and would further enhance the usefulness of this nuclear technique in enabling better management of cancer and other diseases.

There are some types of cancer, such as neuroendocrine cancers, that are best diagnosed and monitored through gallium-68 radiopharmaceutical imaging. As no cyclotron is needed nearby, the establishment of PET/CT facilities using gallium-68 radiopharmaceuticals could be a sustainable starting point for middle and lower income countries to embark on medical imaging of such types of cancer, as well as other infectious diseases.

Aabha Dixit, IAEA Office of Public Information and Communication in collaboration with the Radioisotope Products and Radiation Technology Section, IAEA Department of Nuclear Sciences and Applications

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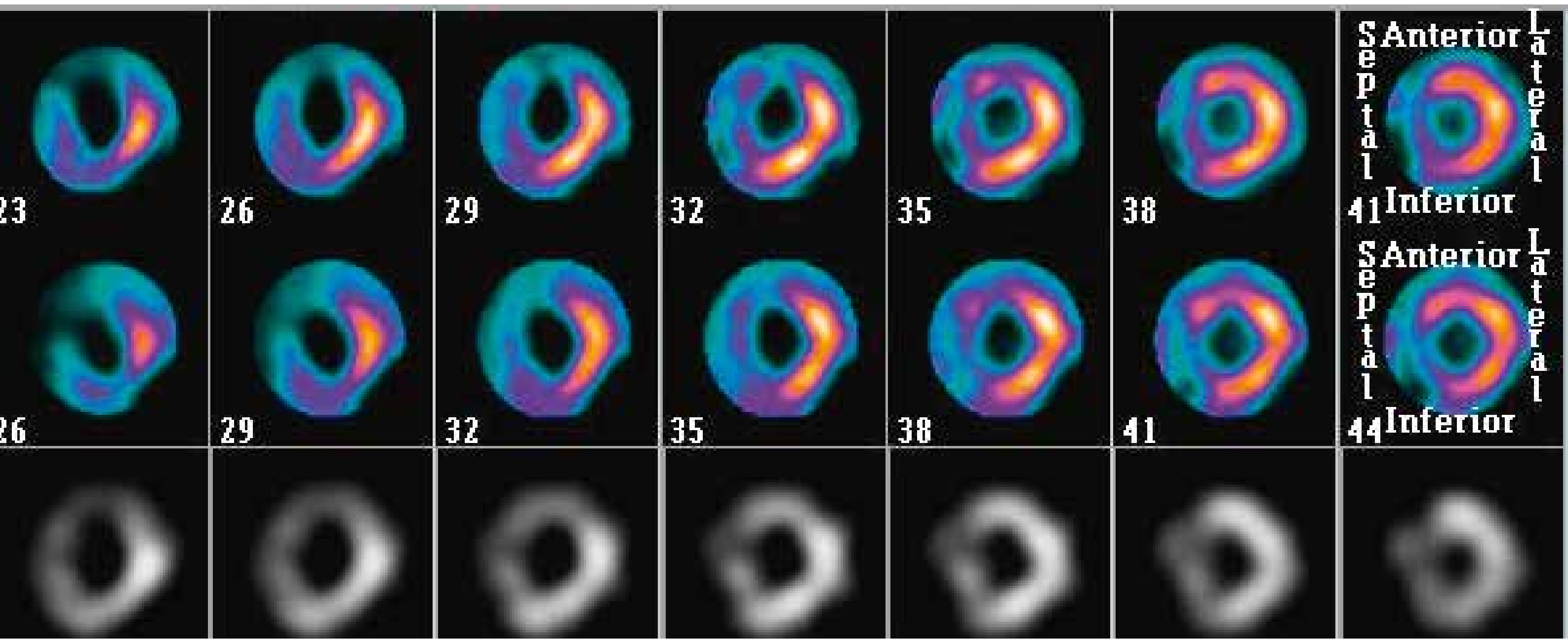
[1] A cyclotron is a complex machine that accelerates charged particles in a vacuum outwards from the centre along a spiral path. During the acceleration process, charged particles gain significant energy. The energized charged particles then interact with stable material that is placed in their path. The interaction transforms stable materials into medically useful radioisotopes that are used to make radiopharmaceuticals.

HELPING YOUR HEART WITH NUCLEAR IMAGING



Myocardial perfusion imaging (MPI) reveals how well the heart muscle is supplied (or perfused) with blood.

(Photo: E. Estrada Lobato/IAEA)

The IAEA is helping in the fight against cardiovascular diseases (CVDs) by assisting its Member States in using nuclear science and technology to track and monitor CVDs. Nuclear imaging techniques allow doctors to look inside a patient's body and see how organs function without running the risk of surgery.

CVDs kill more people than just about anything else on the planet. The World Health Organization (WHO) estimates that roughly 30 per cent of all deaths in 2008 were caused by CVDs. That number is increasing, and by 2030 the WHO estimates that more than 23 million people will die annually from CVDs. For comparison, that is equivalent to roughly the entire population of a medium-sized country.

What are cardiovascular diseases?

CVDs are a group of disorders that can affect a person's heart and blood vessels. They range from diseases that affect blood vessels specific to organs or muscles, like coronary heart disease and peripheral arterial disease, to blood clots, heart birth defects, and damage to the heart muscle from systemic diseases like rheumatic fever. The scope of CVDs is vast and they can affect people from all walks of life. While heart attacks, strokes, and high blood pressure are conditions often associated with the fast-food diets prevalent in rich countries, or countries with aged populations, the truth is that over 80 per cent of CVD deaths occur in low and middle income countries. It is in these countries that assistance is most needed.

Nuclear Imaging for CVDs

Doctors use imaging technology to 'see' inside of a patient's heart and find out how it is functioning and to check its overall condition in order to make a diagnosis. One of the imaging technologies widely promoted is myocardial perfusion imaging (MPI). MPI works by injecting a radiotracer (a compound in which a stable isotope is replaced with a radioisotope that can be followed and traced as it moves within the body) which localizes in the heart muscle of the patient in proportion to the blood supply. The radiotracer emits small amounts of radiation that is picked up by a sensitive camera and processed into images. These images reveal how well the heart muscle is supplied (or perfused) with blood. A patient normally exercises on a treadmill or stationary bike

> **MPI is a 'gatekeeper' technique that is relatively inexpensive, has practically no risk to most of the population — we don't use it on pregnant women — and it tells us a lot about the heart and its functioning.**

during the examination to increase blood flow to the heart and to let the doctor know how the heart performs under physical stress.

Perspectives on CVDs and the IAEA's Role

In October 2014, the IAEA hosted a 'Meeting on regional project design review on the technical cooperation programme for the Latin American region'. During the meeting, Fernando Mut, a nuclear physician working at a clinic in Montevideo, Uruguay, and Amalia Peix, Deputy Director of Research at the Institute of Cardiology in Cuba, shared their personal insights.

Uruguay
Fernando Mut described the important work the Agency does in reaching out to cardiologists in his country and other parts of Latin America by not only raising their awareness of nuclear imaging techniques like MPI, but also by training them in acquiring and using such techniques. Mr. Mut has been recruited several times by the IAEA for educational purposes and has participated in many training courses across the region under the Agency's support.

Left: Fernando Mut, nuclear physician from Montevideo, Uruguay.

Right: Amelia Peix, Deputy Director of Research at the Institute of Cardiology in Cuba.

(Photos: M. Madsen/IAEA)

Mr. Mut explained why MPI is performed before more complex and serious diagnosis procedures and why it is in particular an important technique at his clinic: "MPI is a 'gatekeeper' technique that is relatively inexpensive, has practically no risk to most of the population — we don't use it on pregnant women — and it tells us a lot about the heart and its functioning. There are other ways to measure the functioning of the heart, with ECG (electrocardiography) and echocardiography being safe and non-invasive go-to technologies. Unfortunately, they don't always tell us enough about a patient's condition, and are usually only a first step in identifying a CVD. More thorough diagnostic techniques like angiography (an X-ray imaging technique that involves inserting a catheter into an artery) have a surgical aspect and with it a very small, but present, degree of risk, and so we try to only use it when needed."

Cuba
Amalia Peix, who is the Deputy Director of Research at the Institute of Cardiology in Cuba, noted her country's strong healthcare system. However, there are barriers to increasing the use of MPI in Cuba. These are its prohibitive cost, and the economic embargo that hampers the importation of equipment.

Ms. Peix described the IAEA's support to the Institute and drew attention to an IAEA technical cooperation project about six years ago that, together with contributions from the Cuban government, allowed us to rebuild our clinic's nuclear cardiology department with new equipment and trained staff."

"The IAEA held two workshops and arranged for nuclear cardiology lecturers to visit us. Their support helped train us and find us good gamma cameras.

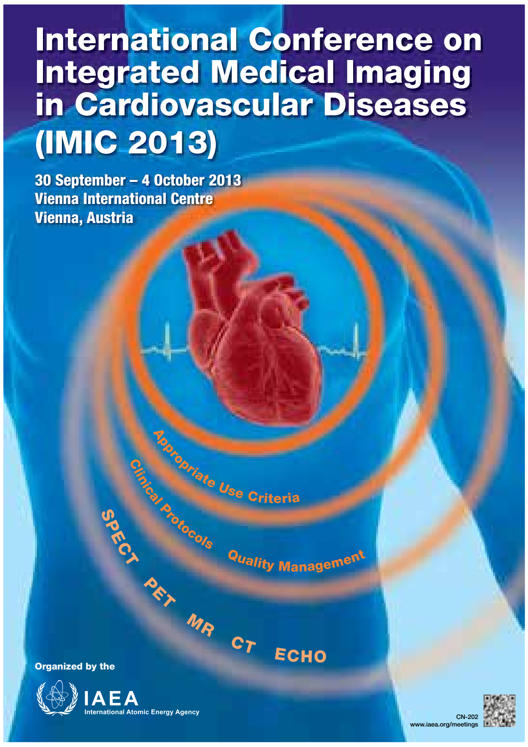
"The IAEA also offered us opportunities to collaborate and share experience in several nuclear cardiology activities. Working with the Agency, we received support for multicentric studies involving developing countries, as well as assistance in disseminating the benefits of nuclear medicine techniques."

"The Institute's patients are open to the idea of nuclear medicine," Ms. Peix said. "Though, usually they have only heard of radiation and nuclear medicine being used on cancer patients, and they get a little concerned when we caution them to stay away from children for a twenty-four hour period after an MPI procedure. We explain to our patients how the procedure does not make them radioactive and that almost all of the technetium [the radioisotope that labels the compounds used as radiotracers in MPI] will leave their body within a day. Fears of radiation are easily overcome with education and this is significant as nuclear techniques are an important tool in diagnosis and guiding us towards appropriate CVD interventions."

Education's role

Education and knowledge sharing is key to dealing with CVDs and actions are being taken to disseminate the latest CVD research globally. In 2013, the Agency held its first International Conference of Integrated Medical Imaging in Cardiovascular Diseases (IMIC 2013), a five-day intensive conference that gathered 350 participants from 91 Member States to exchange knowledge, experience and research findings on the topic of CVDs.

At the conference, the importance of a need for a worldwide initiative to combat the challenge of cardiovascular diseases was highlighted. This would require coordination and partnership of non-governmental international organizations with national governments to increase awareness, to actively promote prevention of CVDs, and to provide efficient and cost-effective assistance in disease management.



The meeting also provided information on how the IAEA meets these needs through its collaborations with Member States and professional societies. These partnerships achieve their goals through the provision of information and educational material, online and on-site training courses, via technical cooperation projects and coordinated research activities.

In addition to IMIC 2013 being accredited by the European Union of Medical Specialists and providing Continuing Medical Education credits to the young medical professionals who attended the conference, it also served as a platform to promote the IAEA's online educational webinars that focus on MPI and computed tomography.

Beyond the Clinic

The IAEA's support in nuclear technology and imaging will only take the fight against CVDs so far, as the frontlines of this battle are actually fought in each and every potential CVD patient. While for some people CVDs may be unavoidable, most CVDs can be prevented by addressing their risk factors and by conducting a campaign promoting prevention. Studies have shown that smoking, physical inactivity and an unhealthy diet can all raise the risk of developing a CVD, yet they are also manageable through lifestyle choices. But even when a country's population achieves a low rate of CVDs, it will still be important that inexpensive and cost-effective options are available for screening and monitoring CVDs, and for that nuclear imaging will continue to be a valuable tool.

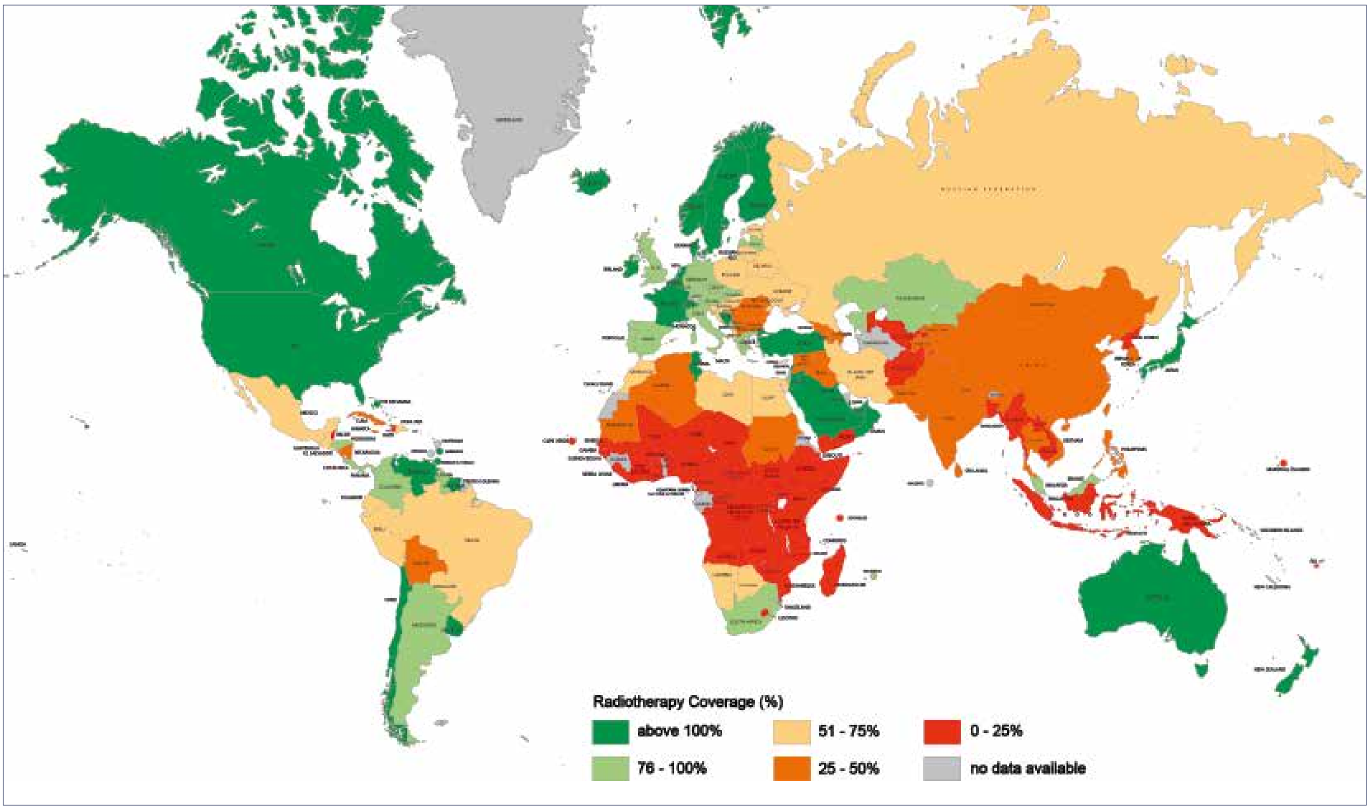
Michael Amdi Madsen, IAEA Office of Public Information and Communication

RAISING AWARENESS, BUILDING PARTNERSHIPS, MOBILIZ
THE ROLE OF THE IAEA 'S DIVISION OF PRO

1 The IAEA works through its Programme of Action for Cancer Therapy (PACT) and in collaboration with the World Health Organization (WHO), the International Agency for Research on Cancer (IARC) and other organizations working in the field of cancer, to provide a coordinated global response to support the implementation of comprehensive national cancer control programmes in low and middle income (LMI) IAEA Member States.

(Photo: PACT/IAEA)

2 Over 30 countries worldwide do not have any radiotherapy machines. PACT, together with its partner organizations, aims to help patients gain access to life saving diagnostic tools, treatment and a better quality of life.



ZING RESOURCES FOR CANCER DIAGNOSIS AND TREATMENT: GRAMME OF ACTION FOR CANCER THERAPY

3 The Virtual University for Cancer Control (VUCCnet) is an IAEA initiative launched in 2010 through PACT that helps to establish training and mentor networks within and amongst LMI countries. The initiative provides a web-based platform to make education materials more easily accessible and affordable for trainees. Today, in Ghana, the United Republic of Tanzania, Uganda and Zambia, most people diagnosed with cancer lose their battle with the disease. To be able to provide comprehensive cancer control for their national populations, these four countries are aiming to train 250 oncologists, over 8000 nurses, 2800 community health workers and other health professionals within the next decade. (Photo: PACT/IAEA)

4 On the occasion of the 58th IAEA General Conference, PACT organized a side event on the value of strategic partnerships in the fight against the global cancer epidemic. The event was attended by IAEA Director General Yukiya Amano, IAEA Deputy Director General and Head of the Department of Technical Cooperation, Kwaku Aning, as well as distinguished delegates from the IAEA Member States and representatives of international organizations.

Tebogo Seokolo, Permanent Representative of South Africa to the IAEA (left), Mitsuro Kitano, Permanent Representative of Japan to the IAEA (left centre), Kwaku Aning, IAEA Deputy Director General and Head of the Department of Technical Cooperation (right centre), Yukiya Amano, IAEA Director General (right).

(Photo: O. Yusuf/IAEA)

5 In 2014, Viet Nam invited PACT to carry out an integrated mission of PACT (imPACT mission). The mission assessed Viet Nam's cancer control needs and the country's capacity to address these needs. ImPACT missions are an entry point through which the IAEA through PACT, the WHO and IARC identify the assistance that they can provide for the development and implementation of a comprehensive cancer control programme.

(Photo: L. Potterton/IAEA)

6 Since 2004, more than 60 countries have benefited from an imPACT mission. Furthermore, ten Member States have already requested an imPACT mission for 2015 to support their fight against cancer.

(Photo: P. Pavlicek/IAEA)

7 In October 2014, the Advisory Group on Increasing Access to Radiotherapy Technology (AGaRT) met at the IAEA headquarters in Vienna. AGarRT is a platform that brings end users of radiotherapy machines from Africa, Asia-Pacific, Europe and Latin America together with main manufacturers of radiotherapy equipment to explore innovative ways to provide affordable, sustainable and suitable radiotherapy solutions in low resource settings. AGaRT was established by PACT in 2009 with the technical support of the IAEA Division of Human Health and the IAEA Division of Radiation, Transport and Waste Safety.

(Photo: N. Falcon Castro/IAEA)

IAEA

Programme of
Action for
Cancer
Therapy
PACT

8 The IAEA's Division of Programme of Action for Cancer Therapy raises awareness, builds innovative partnerships and mobilizes much needed resources to fight cancer.

Text: José Otárola-Silesky, IAEA Division for Programme of Action for Cancer Therapy

GOOD MEDICINE, GOOD HEALTH

The IAEA Promotes Radiation Protection of Patients and Health Professionals

Patient beneath a multi-detector Computed Tomography (CT) scanner (left) which takes detailed images of his heart (right).
(Photo: J. Vassileva/IAEA)

Medical radiation exposure in the form of computed tomography scans, X-rays, fluoroscopy and positron emission tomography scans are the greatest source of exposure to man-made sources of ionizing radiation.

According to the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), more than 10 million diagnostic radiology procedures and 100 000 diagnostic nuclear medicine procedures are performed every day. In addition, around five million radiotherapy treatments are given annually.

The use of radiation in medicine is one of the greatest medical discoveries of the past 120 years. Its use has vastly improved our understanding of the body's processes and functions, as well as our ability to diagnose and cure diseases.

But along with medical exposure to radiation comes a risk of inappropriate use.

The IAEA works to promote strategies and management planning that help protect patients, staff and the public from unnecessary and unintended exposure to ionizing radiation, while promoting good medicine and good health.

Keeping Tabs

In 2012, the IAEA launched Safety in Radiation Oncology (SAFRON), a web-based voluntary reporting system designed to prompt medical centre staff to identify the causes of accidents and near misses in the use of radiotherapy for cancer treatment at their centres, with the aim of preventing these occurrences in the future. By pooling information on the near misses and events, and causality and corrective actions, radiotherapy facilities can develop a safer system to prevent or reduce the likelihood of an event from occurring in the future.

SAFRAD (Safety in Radiological Procedures) is another voluntary reporting system where patients' dose reports and relevant data are included in an international database when these patients have exceeded the defined trigger levels or are submitted to events in fluoroscopically-guided diagnostic and interventional procedures. The primary objective of the system is academic in nature. It is believed that going through the process of using SAFRAD itself results in improved safety and quality of service.

The IAEA also spearheads the Smart Card/SmartRadTrack project, developing methodologies to track radiation exposure of individual patients throughout their lives, no matter which facility/country they visit in order to seek medical care. The project is meant to raise awareness of the lifetime radiation exposure from medical procedures and help doctors treating a patient to confirm that another procedure is necessary and refraining from repeating procedures unnecessarily.

Under the International Action Plan for the Radiation Protection of Patients, a guidance document approved by the IAEA's governing bodies in 2002, the Agency provides standards and training, facilitates knowledge exchange, offers direct technical assistance and builds awareness to improve patient care. In 2013, the joint IAEA and World Health Organization position statement on strengthening radiation protection, the Bonn Call for Action, was issued, identifying responsibilities and proposing priorities for radiation protection in medicine over the next decade.

The 'Triple A Campaign' in Patient Protection: Awareness, Appropriateness and Audit

The IAEA is also working with local authorities and health ministries to change physicians' approach to the use of ionizing radiation on patients via a programme called AAA (awareness, appropriateness and audit).

Awareness: the physician or radiologist must understand the risks associated with exposing patients to various radiation doses, be able to evaluate whether the patient's condition and the potential knowledge and benefits gained from any procedure is likely worth this risk, and be able to communicate the potential risks and benefits to the patient.

Appropriateness: each procedure using ionizing radiation should be suitable for obtaining the information needed to diagnose the patient. Appropriateness criteria, or clinical imaging guidelines, are recommendations that inform the decision of the health care provider on the best imaging test base on patient conditions and available equipment. This may also include a non-ionizing test.

Audit: assess how well and consistently the principles of awareness and appropriateness are being used in the clinical setting. The outcomes from an audit must be integrated in the hospital/clinic's operating life.

Justify and Optimize

The principles of justification and optimization are very important when talking about radiation protection and safety in medicine.

Justification involves judging whether the procedure will potentially improve diagnosis or provide necessary information about the patient, and whether or not the procedure will potentially do more good than harm.

Optimization involves ensuring that the equipment and procedures that are used produce good quality images, while transmitting the lowest possible radiation dose to the patient.

Protecting Workers in Medicine

According to UNSCEAR, more than 7.4 million doctors, technicians, nurses and dentists are involved in the medical use of radiation.

In a report, UNSCEAR notes that the number of occupationally exposed workers in medicine has been increasing rapidly over the years, and individual occupational exposure varies widely among those involved in medical care. There are certain medical procedures that might give substantial doses to medical staff, and the education of medical professionals in radiation protection issues is a continuing problem.[1]

The IAEA initiated the Information System on Occupational Exposure in Medicine, Industry and Research (ISEMIR-IC) project, an international database specifically for interventional cardiology facilities that can be used to identify and improve optimization of occupational radiation protection. This is achieved by collecting information on the worker dose and the procedures used and then by sharing information on best practices for optimization.

The IAEA also provides detailed information on its website (rpop.iaea.org) about radiation-induced cataracts, which may be of concern to the staff involved with interventional medical procedures using X-rays.

Sasha Henriques, IAEA Office of Public Information and Communication

[1] UNITED NATIONS, "Annex B — Exposures of the Public and Workers from Various Sources of Radiation", Sources and Effects of Ionizing Radiation (Report to the General Assembly), Scientific Committee on the Effects of Atomic Radiation (UNSCEAR 2008), UN, New York (2010).

REDUCING RISKS FROM SEALED RADIOACTIVE SOURCES IN MEDICINE[1]

Sealed radioactive sources are commonly used in a variety of medical applications for both diagnosis and therapy. The sources used in medical applications usually have high levels of radioactivity and, therefore, have the potential to cause serious and life threatening injuries if used improperly or maliciously, or risky if they become lost or are stolen.

Sealed radioactive sources used in treatment of diseases include teletherapy sources, which deliver precise doses of radiation from a source outside the patient's body to a well-defined area of the body in order to treat cancer. Teletherapy with sealed radioactive sources commonly uses cobalt-60 as the source of radiation, although some older equipment may use caesium-137. Teletherapy equipment can be used safely and effectively to treat cancerous tumours, but to be effective, it must be properly installed, calibrated, serviced and maintained and should only be used by skilled personnel under appropriate medical supervision. Cobalt-60 sources also need to be replaced regularly, which can be performed only by a licensed source supplier. The preferred option to manage disused sources properly is to return such sources to the supplier after replacement. If this is not possible, disused sources should be disposed of in accordance with national regulatory requirements.

Another common medical use of sealed radioactive sources is brachytherapy, where the sealed radioactive source is placed in direct contact with the patient. It is inserted into a tumour either manually or remotely using special equipment. Remote loading has become much more frequent, as it provides a lower risk of radiation exposure to the medical staff and reduces the risk to patients. Because brachytherapy sources are implanted and subsequently removed, care must be taken to ensure that no source remains implanted following treatment.

Depending on the manufacturers' specifications, some brachytherapy sources need to be replaced every 10 to 15 years. This necessitates not just appropriate procedures for radiation protection during replacement and transfer, but also appropriate procedures and facilities to dispose of all disused brachytherapy sources permanently.

In recent years, sealed radioactive sources have also been used to perform stereotactic radiosurgery, using a device called a Gamma Knife® to perform non-invasive treatment of tumours and other abnormalities in the brain. The technology has not been widely deployed, with only about 200 devices installed worldwide in 2012. In the device, multiple sealed radioactive sources of cobalt-60 are arranged in a circular array in order to focus numerous tiny radiation beams to a defined point inside the brain. These sealed radioactive sources must be replaced periodically and this procedure can only be performed by trained and authorized manufacturer's agents. Following the replacement of radioactive sources, the spent sources that have been removed should be returned to the supplier or manufacturer, or disposed of safely and securely.

Sealed radioactive sources are also used in a medical setting for sterilization, where an object placed in the beam is irradiated at levels that inactivate or kill microorganisms in the irradiated material. This process is done routinely for human blood used for transfusions and may be used for a variety of other purposes. These irradiators include a high-activity source of cobalt-60 or caesium-137 inside a heavily shielded vessel of approximately one meter diameter by one and a half meters tall, although the dimensions vary by manufacturer.

The object to be irradiated is placed inside a chamber designed for that purpose, the chamber secured, and the sources exposed inside the chamber for the length of time necessary to achieve a sterilization dose. The irradiator may contain several individual sources in an array designed to give a uniform irradiation field in the chamber. After some years, it is usually necessary to replace the sources. Such source exchanges may only be performed by trained and authorized manufacturer's agents, with the removed sources returned to the manufacturer for disposal.

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[1] Reproduced from the publication *Sealed Radioactive Sources — Information, resources, and advice for key groups about preventing the loss of control over sealed radioactive sources*, IAEA, October 2013.

Preventing Loss and Theft of Sources

While proper training and experience will reduce the risk of radiation exposure when sealed radioactive sources are used, the vast majority of serious accidents and incidents are usually due to a device and its source that has been lost or stolen. Good operational practices and procedures can reduce such occurrences by preventing a source from becoming lost or stolen in the first place.

The small size and portability of brachytherapy sources are essential for them to perform their intended function, which also makes them more susceptible to being lost, misplaced or stolen. Teletherapy machines and irradiators are significantly larger devices, and it is unlikely that the entire device would be inadvertently lost.

However, after years of not being used at a facility, these devices have been sold to metal recyclers without first having the sealed radioactive source removed. Loss of control in these situations is generally a result of inadequate recordkeeping and inventory management, and workers forget that there is a sealed radioactive source inside the device. The devices are required to be labelled as to their radioactive contents, but such labels may be inadvertently removed or become illegibly worn or damaged.

The most effective means to prevent accidents or incidents with sealed radioactive sources is to adopt work habits and adequate measures that reduce the likelihood of a source becoming lost or stolen. Organizations and companies using sources are responsible for taking the necessary steps to protect the public, the environment, and themselves every time they work with a sealed radioactive source. Sources no longer in use should be returned to the manufacturer, disposed of as radioactive waste, if possible, or conditioned for secure long term storage with the consent of the national regulator.

The radioactive substance within a source is sealed within a protective container. These radioactive substances emit energetic particles or waves, which is called ionizing radiation. Radiation from the sources is used for a specific purpose — by doctors to treat cancer, by radiographers to check welds in pipelines or by specialists to irradiate food to prevent it from spoiling, for example.

Professionals who work routinely with radioactive sources are able to do so safely because of their skill and training and because they are knowledgeable about the safety features and design of the equipment they are using.

When these sources are lost or stolen, however, they can fall into the hands of persons who do not have such training and knowledge or who wish to use them to cause harm intentionally. In such circumstances, radioactive sources may be a serious risk to anyone who comes too close to them, touches them, or picks them up, particularly if the sources are damaged.

THE IAEA WORKS TO IMPROVE MEMBER STATES' CAPABILITIES IN TISSUE ENGINEERING

"TISSUE noun \'ti-(,)shü, *chiefly British* 'tis-(,)yü\ : an aggregate of cells usually of a particular kind together with their intercellular substance that form one of the structural materials of a plant or an animal."

Loss of tissue is one of the most debilitating results of medical conditions such as burns, cancer, cardiovascular disease, and traumatic accidents involving the loss of whole or partial body parts.

Regrowing the lost tissue using either natural or synthetic building blocks is currently the most promising treatment.

The IAEA is helping Member States develop and use tissue engineering technology, a relatively new area focused on the development of new tissue created either from stem cells or synthetically produced biomaterials (including polymers originating from natural materials).

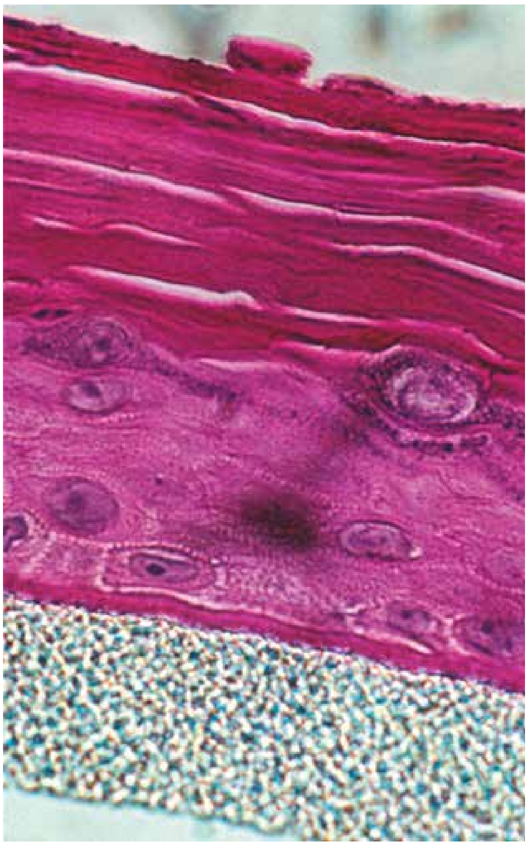
Building Blocks

Many thousands of people suffer from tissue loss every year because of illness or injury. Most countries have developed tissue banks where donated tissue (from cadavers or other sources) is treated and stored. But there is a worldwide shortage of donor tissue in these banks because, for religious, cultural or social reasons, most people do not donate their organs, or the organs of relatives, to medicine after death. Also, there may be no national donor registration programmes to facilitate tissue donation or harvesting.

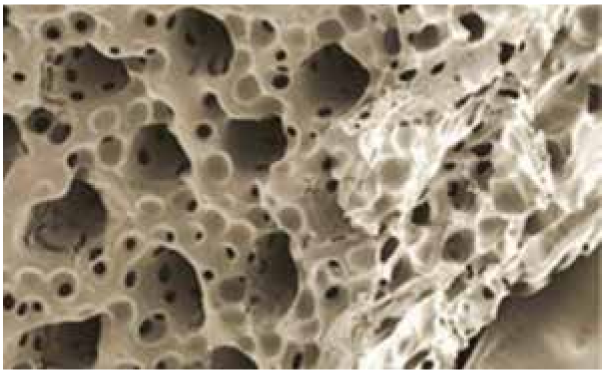
Therefore, countries now see artificial/ engineered tissue as the best solution to the persistent medical problem of tissue loss.

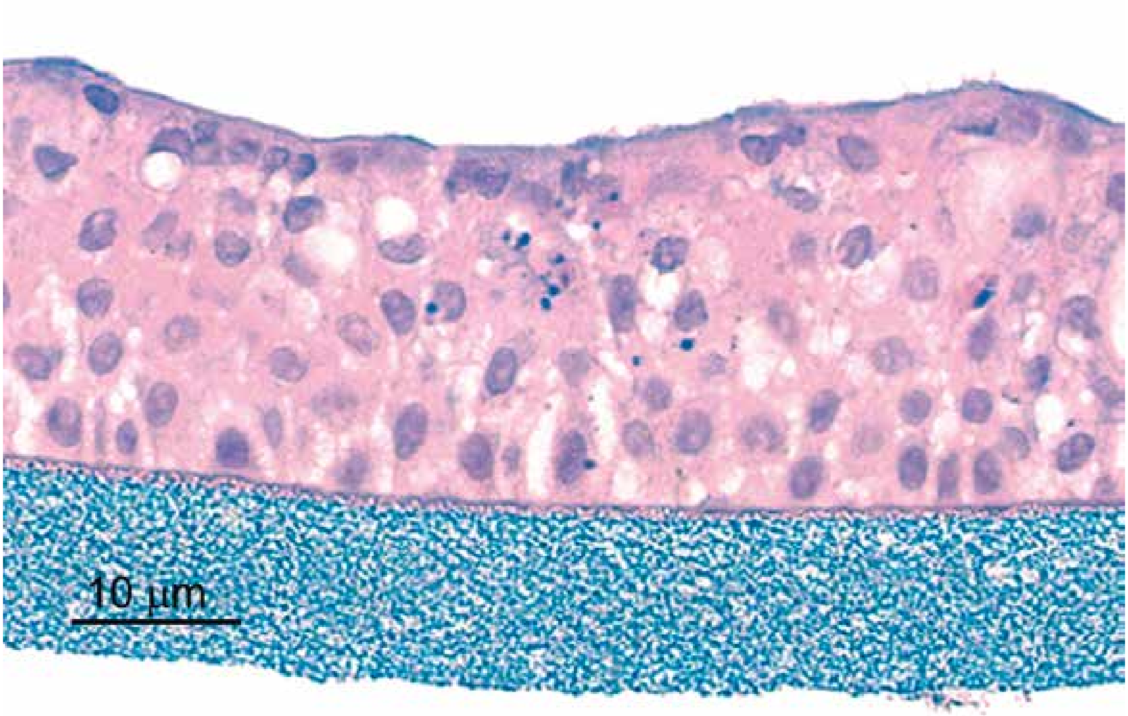
Making tissue scaffolds is one of the first steps in tissue regrowth. Scaffolds are structures with uneven surfaces that promote cell growth (cells won't grow on smooth surfaces) and cell migration (like people, cells like to move around and interact with other cells).

"Give cells the right conditions and the right information and they will make just about anything — a new heart, a new bone, a few feet of new intestine, or part of a liver," says Oleg Belyakov, Radiation Biologist in the IAEA's Applied Radiation Biology and Radiotherapy Section.


Artificial upper layer of skin, the epidermis, which can be used to treat conditions such as burns.
(Photo: MatTek)

"The right conditions for cell growth mean scaffolds, temperature, microenvironments and microarchitecture. The right information can be nudges in the right direction. For example, stem cells used in tissue engineering need growth signals from other cells to let them know what they should become, how they should differentiate," says Agnes Safrany, Radiation Chemist in the IAEA's Radioisotope Products and Radiation Technology Section.


Three-Dimensional heart tissue scaffold with holes of different sizes to promote the growth of nerves, blood vessels, etc. Artificial/ engineered heart tissue can be used to replace portions of the heart that have become necrotic.
(Photo: CRPs F23030 and E31007)



Artificial tracheal/bronchial epithelial human tissue system.
(Photo: MatTek)

Scaffolds provide the framework for cells to build the necessary structures — whether blood vessels, valves, skin, nerves, cartilage, etc. If the tissue scaffold isn't 'just right', the cells will not make the right connections and the engineered tissue will die.

Being 'just right' can mean scaffolding with holes large enough for cell migration during the initial stages of tissue creation, and then holes that are much smaller when the time comes for nerves and blood vessels to be created.

Changing the shape and structure of scaffolding like this can be done quickly and effectively using radiation, which causes no damage to the growing tissue within the scaffold.

Radiation technologies are also instrumental in other areas of tissue engineering, such as surface grafting, killing cells to form a 'feeder layer' for other tissues, and in sterilization.

Tissue engineering, whether combined with traditional tissue banking techniques or not, has the possibility of improving the outcome of medical treatment and decreasing the need for sterilized donor material in the future.

Research and Development

The IAEA's coordinated research project (CRP) on instructive surfaces and scaffolds for tissue engineering using radiation technology began this year and is slated to end in 2018. It is being implemented by both the Division of Human Health and the Division of Physical and Chemical Sciences.

Of the 14 Member States involved, Argentina, Bangladesh, Brazil, Egypt, Malaysia, Mexico, Portugal, Slovakia, Turkey and Uruguay all have limited capabilities in this area, while China, Poland, the UK and USA have advanced knowledge and infrastructure in tissue engineering.

"The CRP is organized in this way so we, and by extension developing Member States, can draw on the expertise of those countries who are leaders in the field," says Belyakov, who is in charge of the project. "Our aim is to provide a forum for knowledge and technology transfer among participating institutions, and facilitate the formation of a network between diverse disciplines (such as chemists, biologists, physicists, medical engineers and material science specialists), as well as promote the early involvement of low and middle income Member States in this quickly developing field."

Sasha Henriques, IAEA Office of Public Information and Communication

USING QUALITY ASSURANCE MECHANISMS TO IMPROVE PATIENT CARE

As technology advances, machines for the diagnosis and treatment of illnesses, including devices that utilize ionizing radiation, continue to become more complex, providing clearer, more detailed images of the body's organs and more effective treatment of diseases like cancer.

For example, state-of-the-art radiotherapy devices allow medical professionals to better shape radiation beams to match cancerous tumours, therefore improving treatment for patients undergoing radiotherapy.

However, if these complex devices are improperly calibrated or incorrectly used, patients may receive the wrong dose of ionizing radiation, a situation that could end up harming patients and medical staff, creating damage where there should be none.

The objective and goal should be to give the correct amount of radiation to produce diagnostic imaging or to treat cancer. In both situations, too much radiation can harm the patient and not enough radiation will produce a diagnostic image that does not have enough information for the physician. In therapy, too little radiation will fail to destroy all malignant cells resulting in tumour regrowth.

To address the problems of overexposure and underexposure of radiation during medical procedures, the IAEA helps Member States to achieve and maintain high standards of professional practice through education and training, and through the establishment and implementation of quality assurance programmes. The IAEA's quality management services, delivered primarily through its technical cooperation programme, allow the Agency to support medical facilities around the world with tools they can use to improve the practice of radiation medicine.

The Agency has developed comprehensive guidelines that can support the auditing process in all disciplines of radiation medicine, namely nuclear medicine (Quality Assurance in Nuclear Medicine — QUANUM), radiation oncology (Quality Assurance Team in Radiation Oncology — QUATRO) and diagnostic radiology (Quality Assurance in Diagnostic Radiology — QUADRIL).

Physicists discussing radiation measurements being taken during a QUATRO audit in Rijeka, Croatia.

(Photo: E. Izewski /IAEA)

QUANUM supports internal and external clinical audits of nuclear medicine, and encourages medical facilities to adopt a culture of consistent review where practices and procedures are routinely audited.

External evaluations of radiation oncology are provided through **QUATRO**, emphasizing quality improvement through the comprehensive review of radiotherapy procedures, structure and process.

QUADRIL supports external clinical audits of diagnostic radiology practices, and concentrates on improving the quality of patient care, and the provision and organization of clinical services.

Although these auditing guidelines might differ in the details of their content, they all share the same basic characteristics, are performed by multidisciplinary teams of experts experienced in the corresponding area of radiation medicine and aim at quality improvement. In order to assist the auditors during the audit process, and at the same time to facilitate an independent review process, standard, detailed questionnaires and audit report forms have been developed and included in the IAEA guidelines.

This auditing process is completely voluntary. However, it is only through a comprehensive clinical audit that a facility can receive a systematic review of the current practice and identification of areas for improvement.

Sasha Henriques, IAEA Office of Public Information and Communication

TRANSCONTINENTAL TRAINING: THE IAEA LAUNCHES ITS DISTANCE ASSISTED TRAINING ONLINE LEARNING PLATFORM — DATOL

At the DATOL event held on the margins of the 58th IAEA General Conference, Member States had the opportunity to learn about this online training programme for nuclear medicine professionals.
(Photo: C. Hofilena/IAEA)

Recent years have witnessed remarkable developments in the field of nuclear medicine; hybrid imaging techniques, novel analytical methods and computed tomography procedures have been broadly adopted by medical facilities around the world. Similarly, there has been a growing awareness that the safe management and use of radiation in medicine depends on the presence of well-trained medical professionals.

While IAEA Member States have made noteworthy investments in nuclear medicine, gaps in expertise remain, especially in low and middle income countries. In some regions, the nuclear medicine discipline has not yet reached the critical mass necessary to justify targeted training programmes. In other regions, the available training programmes do not satisfy the evolving requirements of the field.

In September 2014, the Agency officially launched the Distance Assisted Training Online (DATOL) platform. The platform is available through the Human Health Campus — an IAEA-developed resource for health professionals to find organized and dependable professional educational materials — in order to address these skill gaps.

DATOL will act as an information resource and offer structured access to formative learning. This professional online training platform is intended to develop the knowledge and skills necessary for nuclear medicine professionals to conduct high-quality studies and deliver safe, appropriate medical services.

DATOL's thorough interactive syllabus currently offers 39 subjects, which represent approximately 900 hours of study, and strikes a balance between disciplinary knowledge (theory) and situated knowledge (practice). When pursued part-time, between 5–6 hours per week, the DATOL syllabus can be completed within a 2 to 3 year period.

In order to ensure that the correct skills are cultivated by participants, the distance assisted training platform employs assessment procedures which are standardized on both a regional and interregional level. Each of the nearly 40 subjects includes a set of exercises for which results are recorded to verify course completion.

The Origins of DATOL

Distance assisted training in this field began as a paper-based introduction to nuclear medicine technology.

The origins of DATOL can be traced to a programme introduced by the University of Sydney and the Australian Nuclear Science and Technology Organisation (ANSTO) over 20 years ago. Together they engineered distance assisted training (DAT) where hospitals in IAEA Member States were given an introduction on how to use nuclear medicine in diagnosis and treatment. Following its successful outreach efforts, the DAT was transformed and upgraded into a CD e-learning module, which in turn was followed by the current online version — DATOL.

Today, DATOL is a harmonized, web-based distance learning programme suited for personal study, continuous professional development and formal vocational training for nuclear medicine professionals. The platform offers comprehensive online training resources, which cover fundamental concepts and practical applications. Particular attention is paid to recent developments in emission tomography techniques, including single photon emission computed tomography and positron emission tomography. Although DATOL participants already practice nuclear medicine — a requirement for the programme — they nonetheless benefit from the interactive training tools, visual demonstrations and student support capabilities, which serve to enhance their understanding of the field.

In the medical field, nuclear and radiation techniques are commonly deployed to address a large number of maladies, from infectious disorders to non-communicable diseases such as cancer and cardiovascular disease. Thus far, DATOL has been used to train approximately 800 students in the detection and treatment of these illnesses, most notably in the Latin America, and Asia and the Pacific regions.

Positive Feedback

Despite and the fact that DATOL was launched only recently, feedback has already been gathered regarding the helpfulness of this kind of distance assisted training platform. Especially where the recommended implementation guidelines (which include timetables and strict deadlines) are followed, DATOL has demonstrably improved nuclear medicine practices. During interactive workshops organized in support of DATOL, the IAEA gathered feedback that uncovered notable gains in knowledge, positive changes in attitudes and the adoption of critical new practices. The availability of the nuclear medicine syllabus in Spanish has significantly contributed to the success of the outreach efforts in promoting this innovative online service in Latin America.

The launch of the DATOL platform marks a unique and key milestone in the culmination of substantive efforts and planning, supported through a series of technical cooperation (TC) projects, which have been implemented over the past two decades. The objectives of the TC projects were to progressively develop and harmonize the training syllabus and course material; improve the delivery mechanisms of the online training package; and tailor the course to suit professional development programmes for all nuclear medicine specialists. The learning experience in the online courses of the Human Health Campus is powered by the IAEA's Cyber Learning Platform for Nuclear Education and Training (CLP4NET) — a one window operation with open access to a field of science that provides not only specific modules of information but training as well.

DATOL is also a result of an effective partnership between IAEA Member States, the IAEA Department of Nuclear Sciences and Applications and the IAEA Department of Technical Cooperation, with support from the University of Sydney, University College London and ANSTO.

Soon after its launch at the margins of the 58th IAEA General Conference, a number of queries were received from Member States regarding this online programme. The Islamic Republic of Mauritania and Benin have recently requested additional details to acquire a better understanding of DATOL.

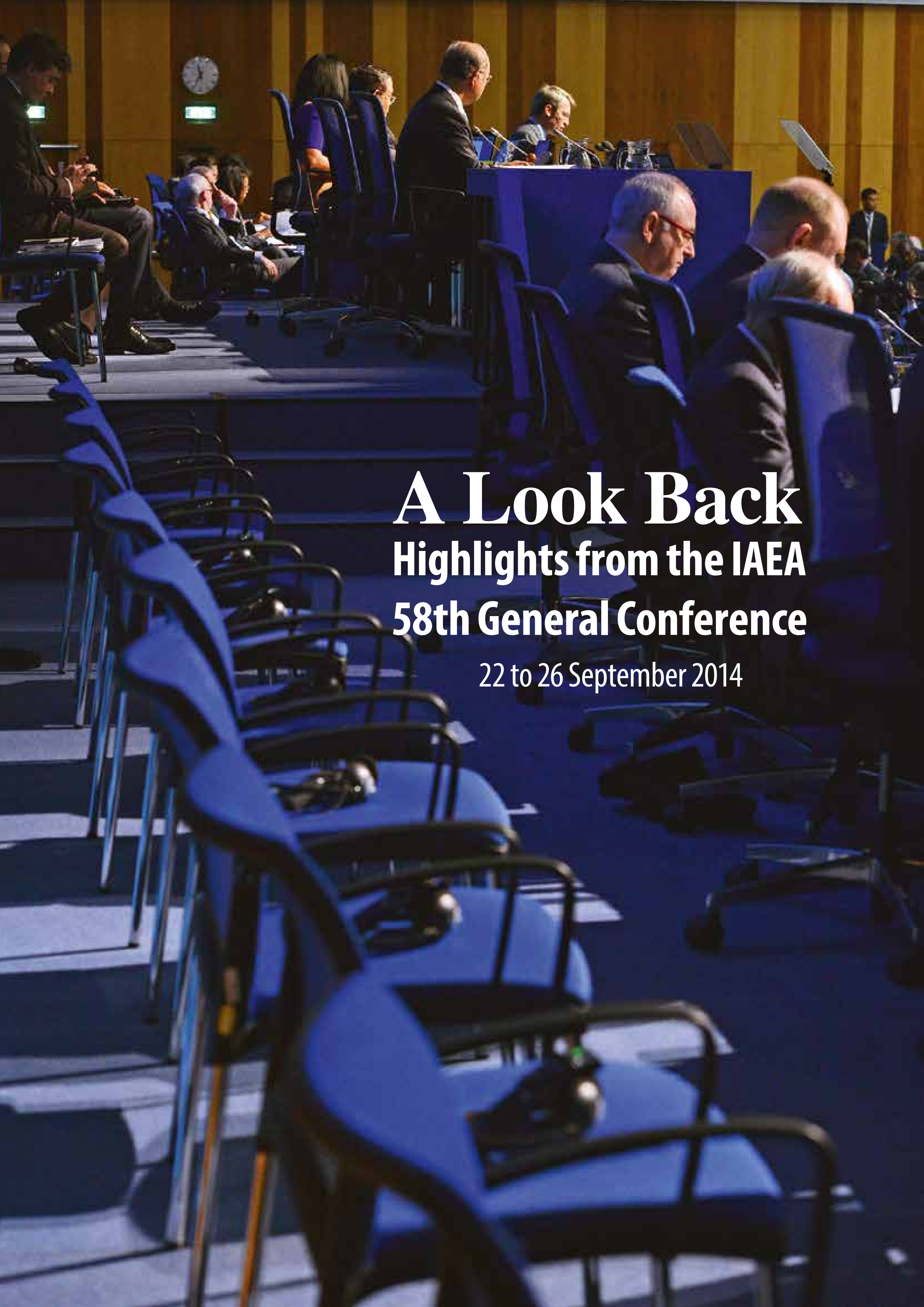
Supporting the IAEA's Mandate

With regard to human health, the technical and infrastructure needs associated with prevention, diagnosis and treatment are often complex and expensive. The IAEA works to facilitate the efforts of Member States in delivering nuclear medicine services, as mandated by Article II of the IAEA Statute, which states that the IAEA shall accelerate and enlarge the contribution of atomic energy to health. Thus developing appropriate training programmes for the broader nuclear medical community is one of the core goals of the IAEA.

DATOL is an expression of that mandate, and will provide accurate, authoritative information with which to train and develop the skills of nuclear medicine professionals from among the IAEA's Member States.

DATOL has provided a learning platform for those countries that need support in first hand medical information and training that can help save lives. It promotes capacity building for nuclear medical professionals in a proactive way that is also cost effective. It enables those in the field of work and education a remarkable opportunity to learn about new concepts and available technologies in the nuclear medical sector.

Omar Yusuf, IAEA Department of Technical Cooperation



A Look Back

Highlights from the IAEA 58th General Conference

22 to 26 September 2014

Opening Day, 22 September 2014

Over 3000 participants gathered at the IAEA headquarters from 22 to 26 September 2014 for the IAEA's 58th General Conference (GC).

The five-day event brought together high-level government representatives and other participants from the IAEA's 162 Member States as well as international organizations, the media and non-governmental organizations.

During the conference, the IAEA's programme and activities were considered and the Agency's budget for the coming year was approved. Each year, General Conference participants are also able to choose from and attend side events held throughout the week.

"The impact of our work in the daily lives of millions of people around the world is extraordinary."

— IAEA Director General Yukiya Amano remarked during his speech to hundreds of delegates during the GC opening session.

GC Side Events Highlighting Radiation Medicine and Technology

23 September 2014

Reducing Unnecessary Exposure to Radiation in Medicine: Side Event Promotes AAA Approach to Patient Radiation Protection and Safety

To reduce the risk of harmful doses of ionizing radiation being given to patients, experts have come up with the AAA (awareness, appropriateness, audit) approach that, if used, will significantly reduce the numbers of radiological procedures done each year and ensure that those procedures that are carried out are in patients' best interests.

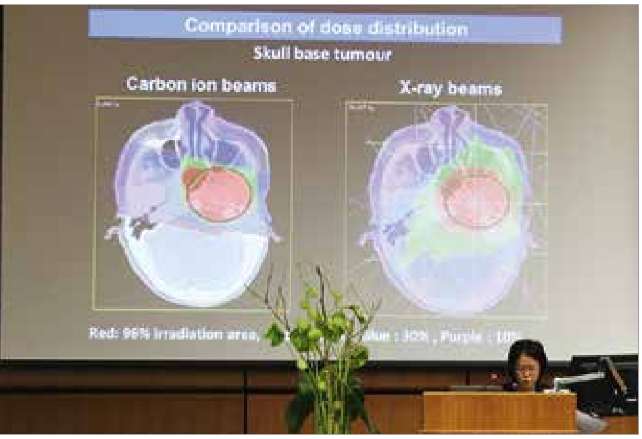
(Photo: S. Henriques/IAEA)

25 September 2014

(Photo: O. Yusuf/IAEA)

Transcontinental Training: The IAEA Launches its Distance Assisted Training Online Platform — DATOL

The Distance Assisted Training Online (DATOL) programme through the IAEA Human Health Campus was launched during a side event at the GC. This IAEA-developed resource provides educational materials intended for nuclear medicine professionals in order to address skill gaps and facilitate the development of the knowledge and skills necessary for conducting high-quality studies and delivering safe and appropriate medical services.



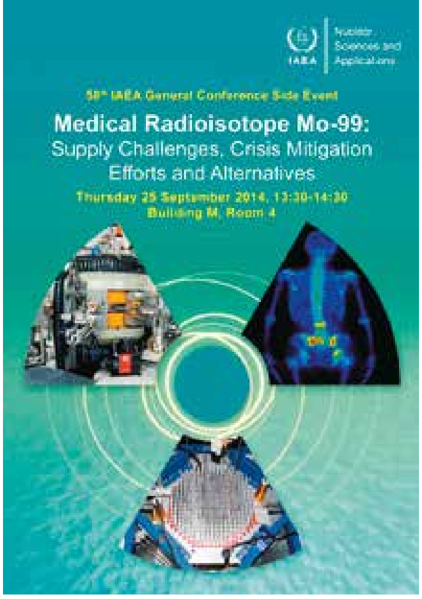
(Photo: N.Jawerth/IAEA)

The IAEA Hosts Event on Particle Radiotherapy for Improved Cancer Treatment

A new radiotherapy approach using charged particles (protons or carbon ions) delivered to a tumour has the potential to offer improved control over tumour growth and requires lower doses of radiation during cancer treatment. Particle Radiotherapy for Cancer: Biology and Technology was the topic of a side event held during the GC.

Averting a Medical Radioisotope Shortage: Supply Challenges, Crisis Mitigation Efforts and Alternatives to Medical Radioisotope Molybdenum-99

An impending shortage of a key radioisotope will have an adverse impact on medical nuclear imaging diagnostics unless alternative methods or substitutes are found. Molybdenum-99 is typically produced in research reactors. It is the parent isotope of technetium-99m, which is a widely used isotope in nuclear medicine. The current state of molybdenum-99 production and potential crisis mitigation options were the topics of three presentations held during the GC side event called Medical Radioisotope Molybdenum-99: Supply Challenges, Crisis Mitigation Efforts and Alternatives.

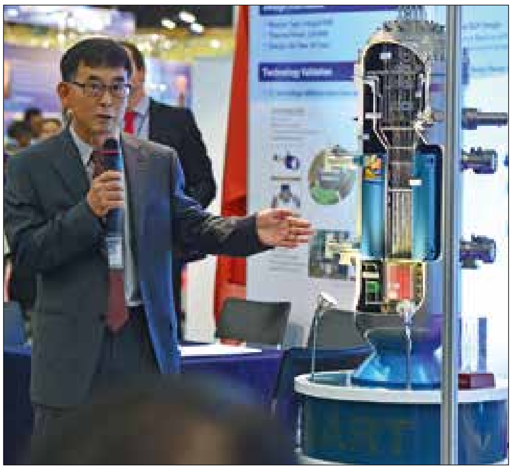


(Photos: C. Hofilena/IAEA)

Touching Lives: Building Partnerships to Fight Cancer

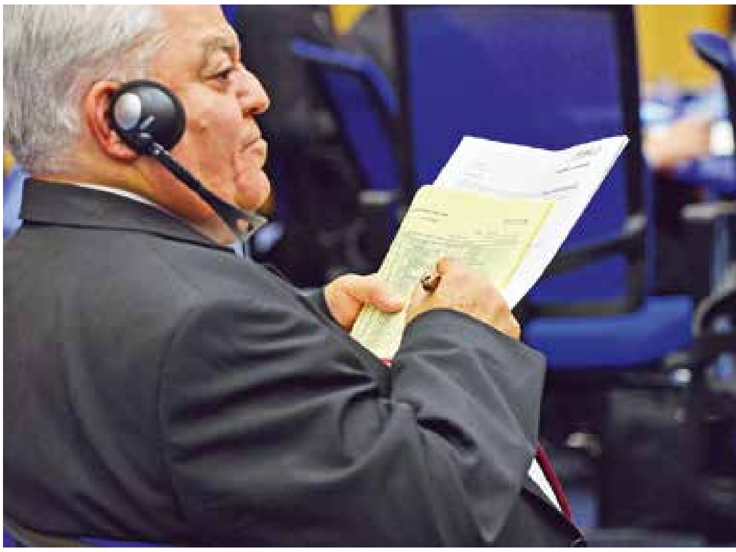
Discussions during the Building Partnerships to Fight Cancer side event focused on strategic partnerships to fight the cancer epidemic in low and middle income countries and called for more to be done to combat one of the most menacing threats to global health. Nelly Enwerem-Bromson, Director of the IAEA Division of Programme of Action for Cancer Therapy and moderator of the event, emphasized that a proactive, strategic and sustained global action to address and invest in the future for cancer control and treatment is critical to saving lives.

In addition to side events related to radiation medicine and technology, dozens of exhibits and side events scheduled throughout the week underlined activities and special programmes being implemented by key departments of the IAEA Secretariat and several Member States.



Closing Day, 26 September 2014

During the Closing Sessions of the General Conference, delegates from IAEA Member States had an opportunity to vote on various topics related to the IAEA, such as resolutions aimed at strengthening the IAEA's work in many areas including nuclear science and technology, safety, security, safeguards and technical cooperation.



Many delegates are eager to participate in the decisions being considered and the important voting process. After lively voting and debate, the General Conference concluded late in the evening on 26 September 2014.

The 59th General Conference will be held next year from 14 to 18 September 2015.

Text compilation: Nicole Jawerth, IAEA Office of Public Information and Communication
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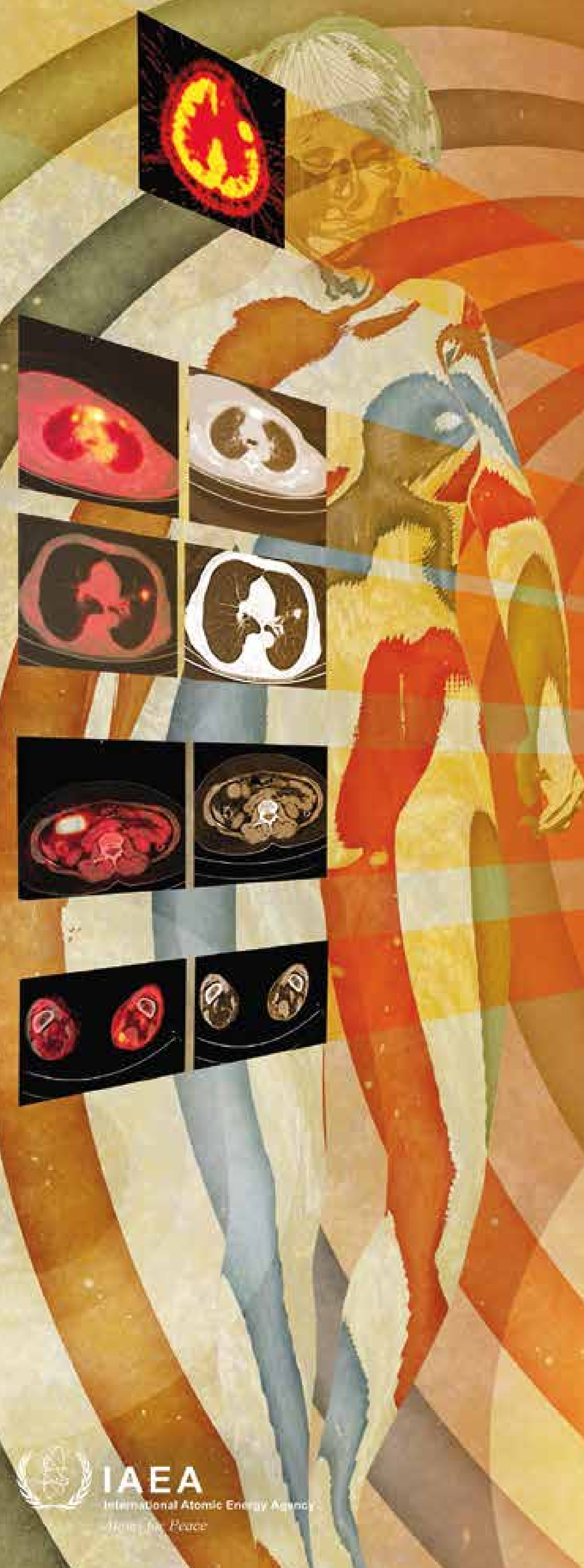

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Vienna, Austria
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